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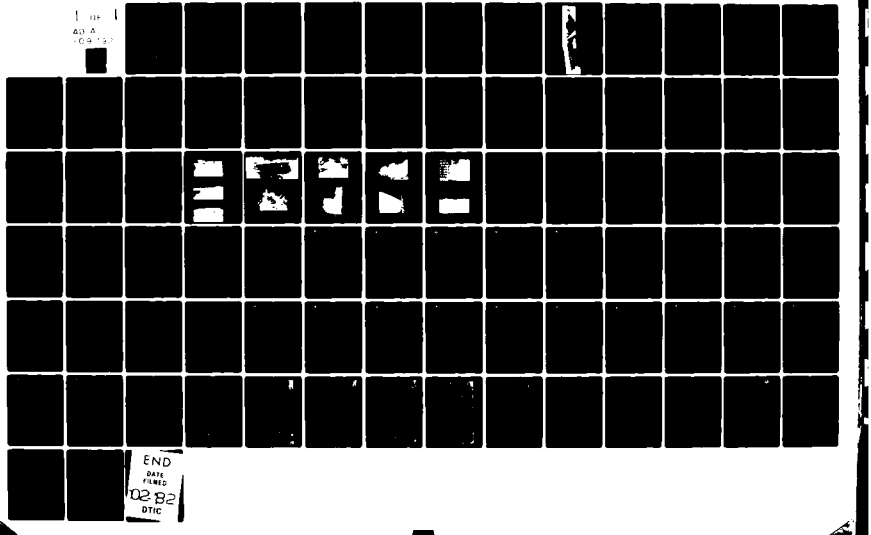

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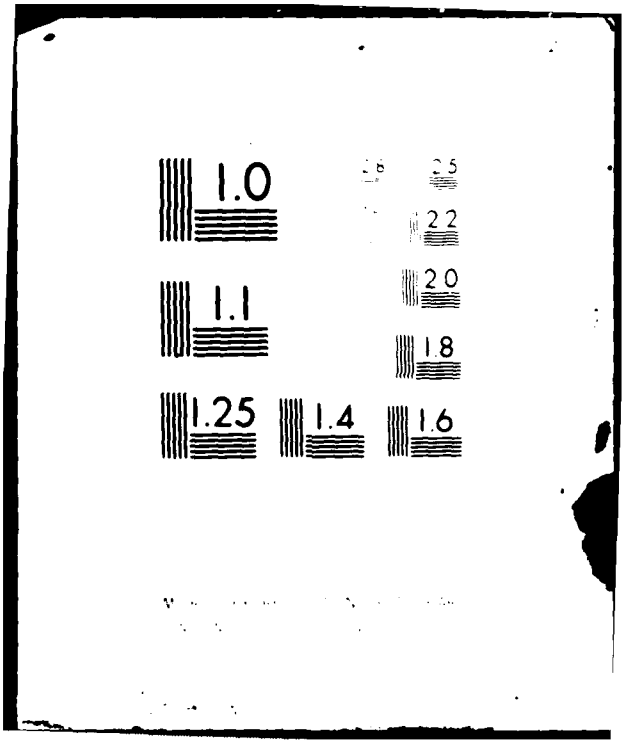
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LOCK 4 EMBANKMENT
WATERFORD FLIGHT DAM
NEW YORK
INVENTORY No. NY 968

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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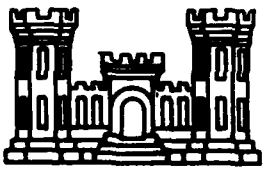

NEW YORK DISTRICT CORPS OF ENGINEERS

AUGUST 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

The examination of documents and visual inspection of the Lock 4 Embankment Waterford Flight Dam did not reveal conditions which constitute an immediate hazard to human life or property. The dam, however, has a number of problem areas which require further investigation and remedial work.

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The hydrologic/hydraulic analysis indicates that the spillway will pass only 8% of the Probable Maximum Flood (PMF). The dam will be overtopped by 3 feet and 0.7 feet by the PMF and 1/2 PMF respectively. Failure of the dam during the 1/2 PMF event would significantly increase the downstream hazard from that which would exist just prior to failure of the dam. The spillway capacity, therefore, is assessed as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that, based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity so that, if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

It is, therefore, recommended that within 3 months of notification to the Owner a detailed hydrologic/hydraulic investigation of the structure should be undertaken to more accurately determine the site specific characteristics of the watershed and their effect upon the overtopping potential of the dam. The results of these investigations will determine the appropriate remedial measures which will be required to achieve adequate spillway capacity. This remedial work should be completed within 18 months. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around-the-clock surveillance of the structure must be provided during these periods.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lock 4 Embankment Waterford Flight Dam I.D. No. NY 968
State Located:	New York
County:	Saratoga
Watershed:	Mohawk River Basin
Stream:	Canal linking Mohawk and Hudson Rivers
Date of Inspection:	May 1, 1981

ASSESSMENT OF GENERAL CONDITIONS

The examination of documents and visual inspection of the Lock 4 Embankment Waterford Flight Dam did not reveal conditions which constitute an immediate hazard to human life or property. The dam, however, has a number of problem areas which require further investigation and remedial work.

The hydrologic/hydraulic analysis indicates that the spillway will pass only 8% of the Probable Maximum Flood (PMF). The dam will be overtopped by 3 feet and 0.7 feet by the PMF and 1/2 PMF respectively. Failure of the dam during the 1/2 PMF event would significantly increase the downstream hazard from that which would exist just prior to failure of the dam. The spillway capacity, therefore, is assessed as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that, based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity so that, if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

It is, therefore, recommended that within 3 months of notification to the Owner a detailed hydrologic/hydraulic investigation of the structure should be undertaken to more accurately determine the site specific characteristics of the watershed and their effect upon the overtopping potential of the dam. The results of these investigations will determine the appropriate remedial measures which will be required to achieve adequate spillway capacity. This remedial work should be completed within 18 months. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around-the-clock surveillance of the structure must be provided during these periods.

The structural stability analysis indicates unsatisfactory stability would result from loadings which could occur under the Probable Maximum Flood (PMF) and 1/2 PMF events. A structural stability investigation should be commenced within 3 months to determine the characteristics of the uplift forces acting on the dam, the properties of the existing dam and foundation, and the effect of these

conditions on the stability of the dam. Remedial work should be undertaken depending on the results of this investigation and completed within 18 months.

The following remedial work should be undertaken within one year:

1. Appropriate steps should be taken to eliminate woodchucks from the embankments and the burrows should be filled.

2. Slopes and crest of the dam should be cleared of trees and brush and a suitable sod cover established to provide easy access for inspection of the facility.

3. The swampy area at the toe of the right embankment should be drained and a system of drainage ditches should be established to allow inspection of the area. This area should then be examined for signs of seepage.

4. The excavation on the slope of the right embankment near the opening into Lock No. 4 should be filled, and the slope restored to its original shape.

5. A formalized inspection system should be initiated to develop data on the conditions and maintenance operations at the facility.

6. A flood warning and emergency evacuation system should be implemented to alert the public in the event conditions occur which could result in failure of the dam.

Dale Engineering Company

John B. Stetson, President

Approved By: for Col. W. M. Smith, Jr.
New York District Engineer

Date: 10 Aug 81

1. Overview of the dam from the impoundment. Roadway at left of the photo is located on the top of the left embankment. Wooded area to right is at top of right embankment.
(Note residences near toe of left embankment.)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LOCK 4 EMBANKMENT WATERFORD FLIGHT DAM I.D. NO NY 968
Mohawk River Basin
Saratoga County, NY

SECTION 1: PROJECT INFORMATION

1.1 GENERAL

a. Authority

Authority for this report is provided by the National Dam Inspection Act, Public Law 92-367 of 1972. It has been prepared in accordance with a contract for professional services between Dale Engineering Company and the U. S. Army Corps of Engineers.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the existing condition of the Lock 4 Embankment Waterford Flight Dam and appurtenant structures, owned by the New York State Department of Transportation, and to determine if the dam constitutes a hazard to human life or property and to transmit findings to the U.S. Army Corps of Engineers.

This Phase I inspection report does not relieve an Owner or Operator of a dam of the legal duties, obligations or liabilities associated with the ownership or operation of the dam. In addition, due to the limited scope of services for these Phase I investigtions, the investigators had to rely upon the data furnished to them. Therefore, this investigation is limited to visual inspection, review of data prepared by others, and simplified hydrologic, hydraulic and structural stability evaluations where appropriate. The investigators do not assume responsibility for defects or deficiencies in the dam or in the data provided.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Lock No. 4 at Waterford is one of a series of six locks located on the Barge (Erie) Canal system which provides a navigation link between the Hudson River near Troy at elevation 14 feet to the Mohawk River at an elevation of 183 feet. The Lock No. 4 facility consists of a V-shaped dam with the lock structure located at the point of the V. The right embankment is approximately 1760 feet long while the left embankment is approximately 1100 feet long. The maximum height of the embankments is approximately 34 feet. A broad-crested weir spillway is located at the right abutment of the right embankment. This spillway is approximately 100 feet long and is constructed of concrete and masonry. The spillway allows excess water which is discharged during the operation of the upstream locks to flow from the impoundment through a bypass channel to the canal downstream from the lock. The embankments at this facility are earthfill structures with a concrete corewall which extends 4 feet into bedrock.

The slopes of the embankment are 1 vertical to 2 horizontal. The upstream face of the embankment is protected by a 2 foot thick layer of rock riprap extending from the crest to the toe. The drainage area contributing to the flow to Lock No. 4 is relatively small under normal conditions. The main function of the embankment is to retain water for navigational purposes in the canal. Flows from the Mohawk River are controlled by the upstream locks (Nos. 5 and 6) and by the Crescent Dam which forms the impoundment for the navigation channel above Lock No. 6.

b. Location

The Lock No. 4 Embankment Waterford Flight Dam is located in the Town of Waterford, Saratoga County, New York, approximately 1/2 mile northwest of the Village of Waterford.

c. Size Classification

The maximum height of the dam is approximately 34 feet. The storage volume of the impoundment is approximately 250 acre feet to the top of dam. Therefore, the dam is in the intermediate size classification as defined by the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

Several residential properties are located just beyond the toe of the dam. Therefore, the dam is in the high hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams.

e. Ownership

The dam is owned by the New York State Department of Transportation.

Contact:

Waterways Maintenance Subdivision
New York State DOT
Building 5, Room 216
1220 Washington Avenue
Albany, New York 12232
Attention: Mr. Joseph Stellato
Telephone: (518) 457-4220

Region 1:

New York State DOT
Region 1 Office
84 Holland Avenue
Albany, New York 12208
Attention: Mr. John Hulchanski
Telephone: (518) 474-6715

f. Purpose of the Dam

The dam is used to maintain a water level for navigational use on the Barge Canal.

g. Design and Construction History

The plans for Lock No. 4 of the Erie Canal are dated 1905. The facilities are reputed to have been built between 1911 and 1915. The plans substantially conform to the present configuration of the facility. No information is available regarding the design or construction history of this dam.

h. Normal Operational Procedures

The water level in the reservoir is maintained by the discharge from the upstream locks. Excess flows are discharged through the spillway and its bypass channel to a point downstream from the lock. The quantity of flow through the impoundment is dependent on canal traffic and the number of lock operations which occur during a given time period. The facility is under constant surveillance during the navigational season by personnel of the Waterways Division of the New York State Department of Transportation. The canal in this area is drained during the non-navigational season.

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of the dam at Lock No. 4 is 0.25 square miles under normal conditions. Under flood conditions, a portion of the flow from the 3455 square mile drainage basin of the Mohawk River above Crescent Dam may contribute flow through the canal system.

b. Discharge at Dam Site

No discharge records are available for this site.

Ungated Spillway, Top of Dam	2890 CFS
Gated Drawdown *	870 CFS

c. Elevation (Barge Canal Datum) **

Top of Dam - Earthfill Section	123.0
Top of Dam - Masonry at the Lock	121.75
Spillway Crest	118.75
Canal Channel Grade at Lock	71.25

* Total flow through 4 foot wide x 5 foot high sluice gated opening and 5 foot wide stop plank opening fully open with reservoir at top of dam.
** Barge Canal datum = USGS + 0.99 feet.

d. Reservoir

Length of Normal Pool	1050 feet

e. Storage

Top of Dam	250 Acre Feet
Spillway pool	195 Acre Feet

f. Reservoir Area

Top of Dam	15 acres
Spillway Pool	13.5 acres

g. Dam

Type - Earth embankment
Length - Right embankment: 1760 feet
Left embankment: 1100 feet
Height - 34 feet
Freeboard between normal reservoir and top of dam - 4.25 feet
Top width - 20 feet
Side slopes- 1 vertical: 2 horizontal
Zoning - 1st class embankment upstream portion
2nd class embankment downstream slope (see plans)
Impervious core - Concrete core wall
Grout Curtain - None

h. Spillway

Type - Uncontrolled weir with inclined crest and rounded downstream corner.
Length - 100 feet
Crest elevation - 118.75
Gates - No gates on spillway
U/S Channel - Reservoir
D/S Channel - Bypass channel cut in rock

i. Reservoir Drain

One 4 foot wide x 5 foot high sluice gate invert 101
One 5 foot wide stop plank opening invert 101

SECTION 2: ENGINEERING DATA

2.1 GEOTECHNICAL DATA

a. Geology

Lock 4 Embankment Waterford Flight Dam is located in the Hudson Valley section of the Valley and Ridge Province. This is a part of the Appalachian Highlands, the major physiographic division.

Bedrock outcroppings are present in the channel wall below the lower gate of the Lock and in the walls and floor downstream of the spillway which is located on the south side of the western end of the Lock basin. As shown on the generalized geologic map in Appendix F, the dam (southwest corner of map) is on Middle Ordovician Canajoharie Shale. This formation generally consists of a soft black carbonaceous, slightly calcareous, shaly claystone. Specimens examined from waste located along the south bank showed the material to be considerably sheared, obviously having been subjected to deformation. Normally this material weathers easily, disarticulates, and on moderate to steep slopes slumps readily. The sheared nature of this shale would tend to exacerbate disarticulation and slumping.

b. Subsurface Investigations

Plans from 1905 indicate that glacial clays and fine sand are overlying the shale. The Lock was to be set in rock and the spillway was to be concrete set on rock, as was seen in the field. Also, the plans indicate that the earth subbase was to be grubbed and the dam core wall was to be set in rock where present. Cross-sections of the north and south embankments indicate that the concrete core would be set in rock in some places, but in clay and fine sand where rock is not present.

There is no indication of the type of treatment, if any, that was to be given to the non-rock base of the core wall, nor is there any indication of any treatment to be given, if any, to the shale rock foundation of the core wall. The shale is not susceptible to solution.

The contract plans included in Appendix F show the location of borings along the length of the contract.

2.2 DESIGN RECORDS

No reports were available from the original design of the dam. The pertinent plans are included in Appendix F.

2.3 CONSTRUCTION RECORDS

No information was available concerning the original construction of the recent repairs to the spillway.

2.4 OPERATIONAL RECORDS

There are no operational records available that are pertinent to the dam safety aspects of this facility. No flow records are kept showing discharge from the facility.

2.5 EVALUATION OF DATA

The data represented in this report was obtained from the New York State Department of Transportation Waterways Division. The information available appears to be reliable and adequate for a Phase 1 inspection report.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General

The Lock 4 Embankment Waterford Flight Dam was inspected on May 1, 1981. The Dale Engineering Company inspection team was accompanied by Al Ferris and John Huntington of the New York State Department of Transportation Waterways Division. During the inspection the weather was fair and the water level in the impoundment was 119.25 feet.

b. Dam

The slopes and the crest of the right embankment of the dam are heavily overgrown with trees and brush. Numerous woodchuck holes were detected along the downstream slope. The crest of the right embankment is uniform in section and no signs of settlement were detected. The slopes of the embankment are uniform with no signs of sloughing or seepage. The area at the toe of the right embankment was swamplike with wetland grasses prevailing from the toe of the embankment to the bypass channel located just beyond the toe of the right embankment. This wet area could be caused by either seepage or poor drainage of the area. Due to the heavy overgrowth in this area, it was impossible to determine the source of the water. The slopes of the earthen fill at the lock structure were similarly overgrown with trees and brush. An excavation has been made in the earth slope at the right side of the lock where it meets the right embankment. This excavation appears to have existed for a long period of time and no signs of instability of the slopes were detected. The left embankment of the dam is similarly overgrown with trees and brush on the slopes. A roadway traverses the crest of the dam for access to the lock. This roadway is uniform in alignment and no signs of settlement were detected. The slopes of the embankment are uniform and no sloughing or seepage was detected in the inspection. A rural highway traverses along the toe of the embankment and no signs of seepage were detected in this area. The upstream slopes of both embankments are protected by a 2 foot thick layer of rock riprap. This protection was observed to be in good condition at the top of the slope. No observations were made below the water line due to the depth of water in the impoundment.

c. Spillway and Appurtenant Structures

The spillway, located at the right abutment of the right embankment, was recently renovated and is in good condition. The spillway discharges through a rock channel into a bypass channel which carries the excess flow into the canal below Lock No. 4. This channel was in good condition and no signs of recent erosion were detected. Two outlet control structures are located on the left abutment of the spillway. These facilities consist of a 4 foot wide x 5 foot high sluice gate which may be used to drain the impoundment, and a 5 foot wide stop plank opening which may similarly be used to drain the facility. The operating mechanism on the

sluice gate was under repair at the time of the inspection. However, both the stop plank structure and the sluice gate were in operating condition.

d. Reservoir Area

No conditions were detected which would indicate areas of slope instability in the reservoir area.

3.2 EVALUATION

The visual inspection revealed several deficiencies on this structure. The following specific items were noted:

1. Woodchuck holes were detected on the downstream face of the embankment.

2. The slopes and crest of the dam were heavily overgrown with trees and brush so as to preclude close inspection of the facility.

3. A swampy area exists at the toe of the right embankment.

4. An excavation exists on the slope of the right embankment near Lock No. 4.

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

The water level in this impoundment is controlled to provide water for navigational purposes in the Barge Canal System. The water level in the impoundment is dependent upon the quantity of water being discharged from the upstream locks. Lock No. 4 is manned around the clock during the navigation season. The system is drained during those periods when the canal is closed.

4.2 MAINTENANCE OF THE DAM

Maintenance and operation of the facility is controlled by the New York State Department of Transportation Waterways Maintenance Division. Water levels are held at optimum level for navigational purposes. Conditions at the site indicate that the facility has suffered somewhat from lack of maintenance. No formalized inspection system is in effect at the facility.

4.3 MAINTENANCE OF OPERATING FACILITIES

Both the gates at the spillway and the operating facilities at the lock are in operating condition and well maintained.

4.4 DESCRIPTION OF WARNING SYSTEM

No warning system is in effect at present.

4.5 EVALUATION

The dam and appurtenances are normally inspected by personnel from the New York State of Department of Transportation Waterways Division although the inspection procedure is not formalized. The following specific items should be addressed by the Owner:

1. A formalized inspection system should be adopted so that changing conditions which might affect the safety of the facility can be readily identified.

2. A flood warning and emergency evacuation system should be implemented to alert the public should conditions occur which could result in failure of the dam.

SECTION 5: HYDROLOGIC/HYDRAULIC

5.1 DRAINAGE AREA CHARACTERISTICS

The dam at Lock No. 4 is located in Waterford, New York. Lock No. 4 is one of a series of locks on the Erie Barge Canal System connecting the Mohawk and Hudson Rivers. Under normal conditions, the contributing drainage area for the dam at Lock No. 4 consists of only about 145 acres and extends upstream to the vicinity of Lock No. 6 at the Mohawk River. However, under high flood flows, flood waters discharging down the Mohawk River may overtop the structure at Lock No. 6 and flow down this section of the canal system to Lock No. 4.

5.2 ANALYSIS CRITERIA

The purpose of this investigation is to evaluate the dam and spillway with respect to their flood control potential and adequacy. This has been assessed through the evaluation of the Probable Maximum Flood (PMF) for the watershed and the subsequent routing of the flood through the reservoir and the dam's spillway system. The PMF event is that hypothetical flow induced by the most critical combination of precipitation, minimum infiltration loss and concentration of run-off of a specific location that is considered reasonably possible for a particular drainage area.

The flood flows for Lock No. 4 were determined using published values for the PMF and 1/2 PMF on the Mohawk River and assessing the relationship of flood flows through the canal system to flood heights on the Mohawk. Due to the limited scope of this Phase I investigation, certain assumptions, based on experience and existing data, were used in this analysis and in the determination of the dam's spillway capacity to pass the PMF. In the event that the dam could not pass 1/2 the Probable Maximum Flood without overtopping, additional analyses are to be performed on potential dam failures if the dam is designated as a High Hazard Classification. This process was done with the concept that, if the dam was unable to satisfy this criteria, further refined hydrologic investigations would be required.

Under normal conditions, the structure at Lock No. 6 prevents flood flows from the Mohawk River from passing down this section of the canal. However, high flood flows on the Mohawk River may result in overtopping of this structure and flood flows passing down the canal. In order to determine the magnitude of the flood flows passing down the canal under the PMF, a discharge rating curve was developed for the structure at Lock No. 6 and combined with the rating curve for Crescent Dam presented in the Phase I Inspection Report for Crescent Dam (Reference 19). Based on the peak discharges for the PMF and 1/2 PMF at Crescent Dam published in "In-Depth Inspection and Evaluation of Needs for Rehabilitation of Crescent and Vischer Ferry Dams" (Reference 20), the height of overtopping of the structure at Lock No. 6 and the accompanying flood discharge through the canal system was computed.

The flows computed at Lock No. 6 were adopted without change for Lock No. 4. Since the drainage area upstream of Crescent Dam is approximately 3455 square miles and the drainage area between Lock No. 4 and the Mohawk River at Crescent Dam is only about 0.25 square miles, the error involved with this assumption is insignificant.

The flood storage area provided between the spillway crest and the top of dam at Lock No. 4 is small in comparison to the volume of water passing the dam under the 1/2 PMF and PMF. Therefore, any attenuation of the flood hydrograph resulting from this storage was neglected and the flood elevations resulting from the 1/2 PMF and PMF are essentially a function of the discharge capacity of the spillway and appurtenant structures only.

The peak for the PMF inflow hydrograph at Crescent Dam on the Mohawk River was 568,000 cfs and the 1/2 PMF inflow peak was 285,000 cfs. Under these conditions 35,340 cfs at the PMF peak and 8260 cfs of the 1/2 PMF peak would overtop the structure at Lock No. 6 and pass down the canal system.

5.3 SPILLWAY CAPACITY

The spillway is an uncontrolled weir with an inclined crest and rounded downstream corner. The 100 foot long spillway has a discharge capacity at the top of dam elevation of 2890 cfs.

SPILLWAY CAPACITY

Flood	Peak Discharge	Capacity as % of Flood Discharge
PMF	35,340 cfs	8%
1/2 PMF	8,260 cfs	35%

5.4 RESERVOIR CAPACITY

The reservoir storage capacity was estimated from the plans included in Appendix F. The resulting estimates of the reservoir storage capacity are shown below:

Top of Dam	250 Acre Feet
Spillway Crest	195 Acre Feet

5.5 FLOODS OF RECORD

There is no information on flood levels at the dam site.

5.6 OVERTOPPING POTENTIAL

The hydrologic/hydraulic analysis indicates that the earth embankment will be overtopped as follows:

Flood	Maximum Depth Over Dam
PMF	3.0 Feet
1/2 PMF	0.7 Feet

Overtopping of the earthen embankment under the 1/2 PMF could lead to serious erosion and eventual failure of the embankment. It is probable that failure of the northern embankment would inundate the residences located directly downslope from this embankment, causing a significant increase in the hazard to loss of life from that which would exist just prior to the overtopping failure.

5.7 EVALUATION

The hydrologic/hydraulic analysis establishes the spillway capacity as 8% of the Probable Maximum Flood (PMF) and 35% of the 1/2 PMF. The dam will be overtopped by 3.0 feet by the PMF and 0.7 feet under the 1/2 PMF. Failure of the earthen embankment could be caused by this overtopping under the 1/2 PMF, significantly increasing the downstream hazard to loss of life from that which would exist just prior to the overtopping failure. Therefore, the spillway is assessed as seriously inadequate according to the Corps of Engineers' screening criteria.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

Lock No. 4 is located some 1200 feet downstream (easterly) from Lock No. 5. The water impounding area for the upper pool level for Lock No. 4 is created by earthen embankment sections which generally form the northerly and southerly limits, the structure for Lock No. 5 and a related embankment which establishes the westerly limit, and the structure for Lock No. 4 which establishes the eastern limit. The water impounding area has a variable width between the locks, with the maximum distance being on the order of 1000 feet. The shipping channel between locks, which is bordered by two concrete dock structures up to 200 feet apart, passes through the center of the impounded area.

The spillway for the impoundment is a 100 foot long concrete structure located near the southwest corner of the impounding area. The spillway's downstream channel generally follows along a route paralleling the length of the lock area's southern embankment.

The spillway has a stepped downstream face. Rock is exposed in the downstream channel immediately below the spillway and it appears that the spillway structure bears on rock. Flow was occurring over this spillway at the time of the inspection and the condition of the concrete in this structure could not be accurately evaluated. The spillway appears to be stable with no indications of misalignment or other structural movements, nor significant loss of section noted. The spillway abutments similarly appear structurally stable, although some deterioration of the surface concrete has occurred near the water line.

The earthen embankment sections appear to be in good structural condition, with no indication of misalignment, sloughing or seepage noted. The downstream slope of the southern embankment is heavily overgrown with trees and brush. A marsh-like surface exists adjacent to the downstream toe area of the southern embankment near the location of Lock No. 4. It appears that this condition is due to stagnant land drainage related to periodic overflow of a shallow downstream spillway channel, although it could represent embankment-lock seepage.

The walls for Lock No. 4 appear structurally stable, although the exposed concrete wall surfaces have experienced spalling and deterioration, particularly at locations of horizontal and vertical joints. The downstream face of the Lock's downstream left abutment is experiencing seepage which possibly enters from the Lock through the gate mechanism behind the abutment wall.

b. Design and Construction Data

No information regarding the structural stability of the spillway or embankment sections has been made available. The existing facility substantially conforms to the information indicated by the drawings included in

Appendix F . These plans indicate the concrete spillway structure is situated on rock. The spillway has a maximum height of about 12 feet at the left (easterly) abutment. The foundation rock slopes upward from the spillway's left abutment towards the right abutment. Rock was excavated for the westerly segment of the spillway to obtain a constructed spillway section at least 4 feet, approximately, in height.

The design plans indicate the earthen embankments are constructed with a concrete core wall which penetrates below the base elevation of the embankment section. It is not certain which sections of embankment have the core wall extending into rock. The water impounding side of the embankments are estabilished at a slope of 2 horizontal to 1 vertical with a "wash wall" for protection against erosion. The downstream sides are constructed at a slope of 2:1 for the upper sections, and flattening to 3:1 and 4:1 for the lower sections.

c. Operating Records

Operating and maintenance records relating to this facility have not been obtained. It is understood that the New York State Department of Transportation does perform periodic inspections of all lock facilities under their jurisdiction, and plan programs for repair and maintenance for the facilities most in need of repairs.

d. Post Construction Changes

No information has been obtained to indicate that post-construction changes for components of the lock facilities have been undertaken. Personnel of the New York State Department of Transportation accompanying the inspection team did indicate that the spillway structure was rehabilitated including the provision of a gunite/shotcrete surfacing in 1976.

e. Seismic Stability

Due to deformation, bedding orientation of the shale is variable. The strike ranges from N40-60°E and the dip ranges from 45° to 80° southeast.

As shown on the geologic map in Appendix F, numerous faults exist in the area. Both thrust and strike-slip faults are common. The thrust plate located a short distance to the west of the Lock is a plate pushed into the area from its original position to the east. It is actually a plate of older material overlying younger rock. The fault line shown merely represents the edge of a plate remnant and does not represent a fault zone that extends into the subsurface. No known fault is present in the vicinity of the dam and no earthquake activity has been recorded in the immediate vicinity of the dam.

Although the area is located within Zone 2 of the Seismic Probability Map, there is a potential for damage equivalent to a Zone 3 designation. The inherrent weakness of shale, high ductility, should be recognized when considering deformation.

Earthquakes record in the area are tabulated below:

Date	Intensity-Modified Mercalli	Location Relative to Dam
1847	II	11 miles SW
1877	II	11 miles W
1888	III	11 miles W
1907	IV	16 miles W
1916	IV-V	17 miles WNW
1955	V	11 miles NW
1958	IV	12 miles SW
1972	III	11 miles W

6.2 STRUCTURAL STABILITY ANALYSIS

Drawings included in Appendix F show the plan layout for the lock facility and structural cross-sections for the spillway and earthen embankments, but do not include specific engineering information on the properties of the materials of construction and the site's foundations, nor stability analysis.

As part of the present investigation, stability evaluations have been performed for the spillway section. Actual properties of the spillway's construction materials and foundations were not determined as part of this study; where information on properties were necessary for computations but lacking, assumptions felt to be practical were made. Analyses have been performed for a section adjacent to the left (east) abutment (the location where the spillway section has the greatest height because of the low elevation of the foundation rock) and for a section near the midlength of the spillway.

The loading conditions studied were for: (i) an impounded water pool at the spillway crest, (ii) the pool at the 1/2 PMF level, (iii) the pool at the PMF level, and (iv) the pool level at the spillway crest with seismic effects included.

The analysis indicates that the spillway structure possesses adequate stability against overturning and sliding when subjected to loading conditions occurring during normal summer operations (impounded water level at the spillway crest). Marginally adequate stability is indicated for the case of the normal summer operations condition with seismic effects included. Inadequate stability against the effects of overturning is indicated for the condition of the 1/2 PMF loading case, and for the PMF loading case. (According to the Recommended Guidelines for Safety Inspection of Dams, unsatisfactory stability exists when the factor of safety is less than unity; and where the resultant of forces acting on the structural section is located outside the middle third of the base, tensile stresses would develop in the section, a condition which is structurally undesirable.)

The results of the analysis are summarized in the tables on the next two pages. The stability computations are presented in Appendix E.

Critical to the analysis and resulting indication of stability are the items of uplift water pressure acting on the base of the dam and the relative permeability of the site's foundation rock. For the "normal operations" case, the analysis uplift force was based on a full headwater hydrostatic pressure acting on the dam's upstream corner and a zero tailwater hydrostatic pressure acting on the dam's downstream corner. Uplift pressures were assumed to vary linearly between the dam's upstream and downstream corners, and to act upon 100 percent of the dam base. The resulting uplift force represents a condition that is significant to indications of instability. Uplift as computed for the normal operating condition was also assigned to the flood conditions studied, assuming that uplift pressures would not increase significantly over a relatively short flood stage time period because of expected low foundation rock permeability.

Further investigation is recommended for the spillway structure, with the thought that methods to improve the stability of the spillway will have to be developed. Because of the influence on structural stability, additional studies should include evaluation of uplift pressures which act upon the base of the spillway. The engineering properties of the foundation rock should also be determined, in order to analyze resistance to displacement and obtain data relative to providing an anchorage system for the spillway section.

The concrete core-earthen embankment sections appear structurally stable. The downstream face of the south embankment is overgrown with trees and brush which interferes with accessibility to the slope for inspecting for seepage or other structurally significant conditions which would require corrective/remedial work. It is recommended that trees and heavy brush be removed to: permit the establishment of an erosion resistant grass or other ground cover, to remove the danger that a storm condition could uproot trees creating the opportunity for erosion, and to permit inspections of the slope which will readily identify signs of embankment seepage, sloughing, etc.

The concrete left abutment for the downstream gate of Lock No. 4 indicates an ongoing seepage condition. This condition should be investigated. Similarly, the extent and effect of deterioration noted for the lock walls should be investigated.

RESULTS OF STABILITY COMPUTATIONS
MIDLENGTH SPILLWAY SECTION

	Loading Condition	Factor of Safety* Overturning	Factor of Safety* Sliding**	Location of Resultant Passing through Base***
(1)	Water level at spillway elevation, uplift on base (no ice)	1.82	60±	0.41b
(2)	Water levels against upstream face and downstream face based on 1/2 PMF elevations, uplift same as Case 1	1.1	20±	0.09b
(3)	Water level against upstream face and downstream face based on PMF elevations, uplift same as Case 1	0.95	16±	Outside Base F.S. < 1.0
(4)	Water level at spillway elevation, uplift on base, seismic effects applicable to Zone 2	1.64	40±	0.37b

* These factors of safety indicate the ratio of moments resisting overturning to those moments causing overturning, and the ratio of forces resisting sliding to those causing sliding. Upstream and downstream water levels were obtained from hydrologic/hydraulic analysis.

** As determined applying the shear-friction method.

*** Indicated in terms of dam's base dimension, b, measured from the toe of the dam.

RESULTS OF STABILITY COMPUTATIONS
MAXIMUM SPILLWAY SECTION

	Loading Condition	Factor of Safety* Overturning	Factor of Safety* Sliding**	Location of Resultant Passing through Base***
(1)	Water level at spillway elevation, uplift on base (no ice)	1.51	17±	0.33b
(2)	Water level at spillway elevation, uplift on base plus 5 kips per lineal foot ice load	0.73	8±	Outside Base F.S. < 1.0
(3)	Water levels against upstream face and downstream face based on 1/2 PMF elevations, uplift same as Case 1	1.02	9±	0.02b
(4)	Water level against upstream face and downstream face based on PMF elevations, uplift same as Case 1	0.89	8±	Outside Base F.S. < 1.0
(5)	Water level at spillway elevation, uplift on base, seismic effects applicable to Zone 2	1.37	14±	0.26b

* These factors of safety indicate the ratio of moments resisting overturning to those moments causing overturning, and the ratio of forces resisting sliding to those causing sliding. Upstream and downstream water levels were obtained from hydrologic/hydraulic analysis.

** As determined applying the shear-friction method.

*** Indicated in terms of dam's base dimension, b, measured from the toe of the dam.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

The Phase I Inspection of the Lock 4 Embankment Waterford Flight Dam did not indicate conditions which would constitute an immediate hazard to human life or property.

The hydrologic/hydraulic analysis indicates that the spillway will pass only 8 percent of the PMF. The dam will be overtopped by 3 feet and 0.7 feet by the PMF and 1/2 PMF, respectively. The failure of the dam during the 1/2 PMF event would significantly increase the downstream hazard from that which would exist just prior to failure of the dam. The spillway capacity, therefore, is assessed as seriously inadequate.

The structural stability analysis indicates unsatisfactory stability would result from loadings which could occur under the Probable Maximum Flood (PMF) and 1/2 PMF events.

The following specific safety assessment is based on the Phase I visual examination, analysis of hydrology/hydraulics, and structural stability analysis.

1. The slopes and crest of the dam were heavily overgrown with trees and brush so as to preclude close inspection of the facility.

2. A swampy area exists at the toe of the right embankment. This condition could indicate seepage from the dam or poor local drainage.

3. Woodchuck holes were detected on the downstream face of the embankment.

4. An excavation has been made on the slope of the right embankment near the opening into Lock No. 4.

5. No formalized inspection system is presently in effect at the facility.

6. No warning system is presently in effect to alert the public should conditions occur which could result in failure of the dam.

b. Adequacy of Information

The information available is adequate for this Phase I Investigation.

c. Urgency

The Owner should immediately implement a program of surveillance during heavy rainfall conditions. Within three months, a flood warning and emergency evacuation plan should be implemented. The remaining items set forth in the safety assessment should be addressed by the Owner and appropriate improvements and repairs should be performed within 12 months of this notification. The recommended investigations should begin within 3 months and the remedial work determined by these investigations should be completed within 18 months.

d. Need for Further Investigation

A structural stability investigation should be performed to determine the characteristics of uplift forces acting on the dam, the properties of the existing dam and foundation, and the effect of these conditions on the stability of the dam. Remedial work should be undertaken depending on the results of this investigation.

A detailed hydrologic/hydraulic analysis to more accurately determine site specific characteristics of the watershed should be undertaken to determine the necessary measures to provide adequate spillway capacity. The remedial work necessary to provide this capacity should be undertaken depending on the results of this investigation.

7.2 RECOMMENDED MEASURES

The following is a list of recommended measures to be completed within 12 months:

1. The slopes and crest of the dam should be cleared of trees and brush and a suitable sod cover established to provide easy access for inspection of the facility.

2. The swampy area at the toe of the right embankment should be drained and a system of drainage ditches should be established to allow inspection of the area. This area should then be examined for signs of seepage.

3. Appropriate steps should be taken to eliminate woodchucks from the embankments and the burrows should be filled.

4. The excavation on the slope of the right embankment near the opening into Lock No. 4 should be filled, and the slope restored to its original shape.

5. A formalized inspection system should be initiated to develop data on the conditions and maintenance operations at the facility.

6. A flood warning and emergency evacuation system should be implemented to alert the public in the event conditions occur which could result in failure of the dam.

APPENDIX A

PHOTOGRAPHS

2. Earth slope at the left side of Lock No. 4.

3. Top of right embankment.

4. Slope of left abutment.

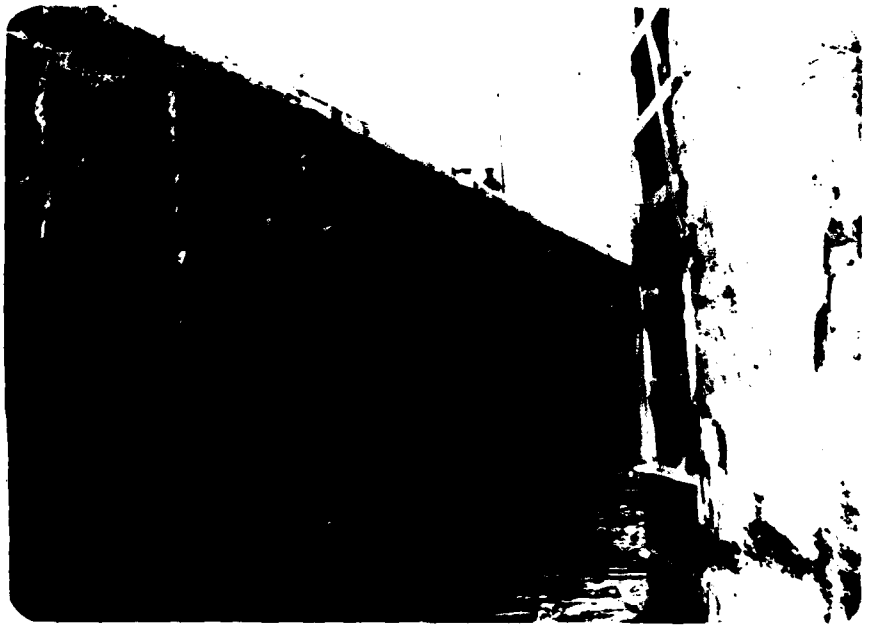
5. Spillway located at the end of right embankment.

6. By-pass channel below spillway.

7. Crest of spillway. Operating mechanism for sluice gate drain is under repair.

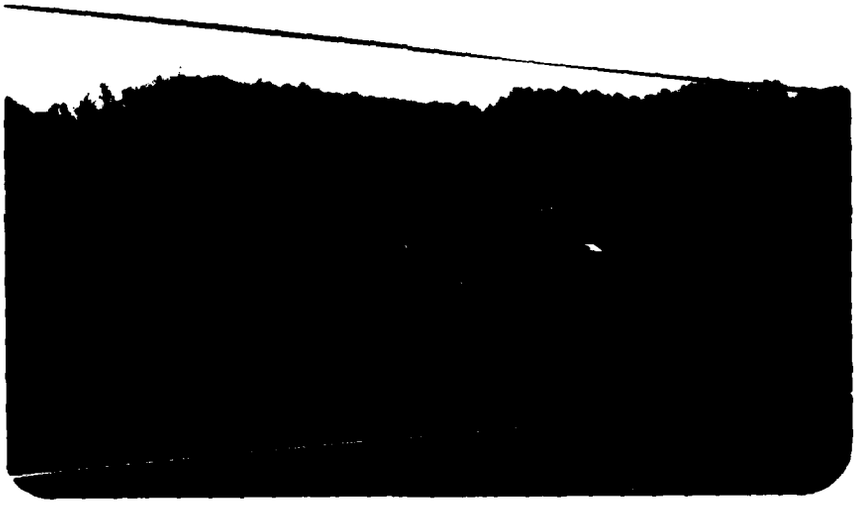
8. Outlet of reservoir drain.

9. Excavated area at the junction of the right embankment and the earth slope of the lock.



10. Right wall of Lock No. 4 showing deteriorated joints in concrete.

11. Minor seepage through concrete at left wall of downstream lock gate.



12. Residences near toe of left embankment.

APPENDIX B

VISUAL INSPECTION CHECKLIST

3-15-3(9/80)

VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam LOCK 4 EMBANKMENT WATERFORD FLIGHT DAM

Fed. I.D. # NY 968 DEC Dam No. _____

River Basin MOHAWK

Location: Town WATERFORD County SARATOGA

Stream Name MOHAWK RIVER (BARGE CANAL

Tributary of HUDSON RIVER

Latitude (N) 42-48.1 Longitude (W) 73-41.7

Type of Dam EARTH FILL

Hazard Category HIGH

Date(s) of Inspection MAY 1, 1981

Weather Conditions FAIR 55°

Reservoir Level at Time of Inspection 119.25

b. Inspection Personnel F.W. RYSTEWSKI, J.A. GOMEZ, D.F. McCARTHY
H. MUSKATT - DALE ENGINEERING CO. JOHN HUNTINGTON, AL FERRIS - NYS DOT WATERWAYS SECTION 2

c. Persons Contacted (Including Address & Phone No.)

JOHN HULCHANSKI - WATERWAY ENGINEER

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

REGION 1 OFFICE TELEPHONE 518-474-6715
84 HOLLAND AVENUE
ALBANY N.Y. 12208

d. History:

Date Constructed 1911-1915 Date(s) Reconstructed spillway repaired 1976

Designer STATE ENGINEER

Constructed By UNKNOWN

Owner NEW YORK STATE DEPT OF TRANSPORTATION

2) Embankment

a. Characteristics

(1) Embankment Material EARTH FILL – 1ST CLASS EMBANKMENT AND 2ND CLASS EMBANKMENT ARE UNDEFINED AS TO TYPE OF MATERIAL

(2) Cutoff Type CONCRETE CORE WALL EXTENDS 4 FT INTO ROCK

(3) Impervious Core CONCRETE CORE WALL

(4) Internal Drainage System NONE

(5) Miscellaneous N/A

b. Crest

(1) Vertical Alignment UNIFORM NO DEPRESSIONS OR DISPLACEMENT NOTED

(2) Horizontal Alignment UNIFORM NO MISALIGNMENT NOTED

(3) Surface Cracks NONE OBSERVED

(4) Miscellaneous RIGHT EMBANKMENT OVERGROWN WITH TREES AND BRUSH.

c. Upstream Slope

(1) Slope (Estimate) (V:H) 1:2

(2) Undesirable Growth or Debris, Animal Burrows TREE GROWTH NEAR TOP OF SLOPE.

(3) Sloughing, Subsidence or Depressions NONE OBSERVED

(4) Slope Protection 2 FT. THICK "WASH WALL" OF ROCK FROM CREST TO TOE. CONDITION GOOD AT TOP, NOT OBSERVED BELOW WATER LINE.

(5) Surface Cracks or Movement at Toe NOT OBSERVED

d. Downstream Slope (SEE TYPICAL SECTION)

(1) Slope (Estimate - V:H) 1:2 TOP 12ft 1:3 MIDDLE 14', 1:4 AT TOE

(2) Undesirable Growth or Debris, Animal Burrows OVERGROWN WITH TREES AND BRUSH. SEVERAL WOODCHUCK HOLES

(3) Sloughing, Subsidence or Depressions UNIFORM NO SLOUGHING, SUBSIDENCE OR DEPRESSIONS OBSERVED.

(4) Surface Cracks or Movement at Toe NONE OBSERVED

(5) Seepage EXTENSIVE WET AREA AT TOE OF RIGHT EMBANKMENT. COULD BE POOR SURFACE DRAINAGE. NO DISTINCT EVIDENCE OF SEEPAGE.

(6) External Drainage System (Ditches, Trenches; Blanket) NO PROVISIONS ON RIGHT EMBANKMENT, LEFT EMBANKMENT HAS DITCH ALONG PARALLEL ROADWAY

(7) Condition Around Outlet Structure GOOD CONDITION. RECENTLY (1975) REHABILITATED.

(8) Seepage Beyond Toe SEE (5) ABOVE.

e. Abutments - Embankment Contact

NO SEEPAGE OBSERVED.

(1) Erosion at Contact NONE OBSERVED

(2) Seepage Along Contact NONE OBSERVED

3) Drainage System

a. Description of System NONE

b. Condition of System N/A

c. Discharge from Drainage System N/A

4) Instrumentation (Momumentation/Surveys, Observation Wells, Weirs, Piezometers, Etc.) NONE

5) Reservoir

a. Slopes NATURAL SLOPES SHOW NO SIGNS OF INSTABILITY

b. Sedimentation NO SIGNIFICANT SEDIMENTATION. (PER DOT)

c. Unusual Conditions Which Affect Dam

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.) SEVERAL HOMES IMMEDIATELY BELOW DAM (SEE PHOTOS)

b. Seepage, Unusual Growth NO SEEPAGE OBSERVED

c. Evidence of Movement Beyond Toe of Dam NONE OBSERVED

d. Condition of Downstream Channel CHANNEL BELOW OVERFLOW SPILLWAY IN GOOD CONDITION. NO RECENT EROSION.

7) Spillway(s) (Including Discharge Conveyance Channel)

100 FT LONG SPILLWAY REHABILITATED (1975-1976)

a. General SPILLWAY DISCHARGES THE EXCESS FLOW FROM LOCK # 5

b. Condition of Service Spillway GENERALLY GOOD CONDITION SOME DETERIORATION AT BASE OF SLUICE GATE OPENING. SOME CRACKING OF CONCRETE AT STOP PLANK OPENING. (SEE PHOTOS)

c. Condition of Auxiliary Spillway NONE

d. Condition of Discharge Conveyance Channel CHANNEL
BELOW SERVICE SPILLWAY IN GOOD CONDITION
NO RECENT OR EXTENSIVE EROSION DETECTED

8) Reservoir Drain/Outlet

Type: Pipe _____ Conduit _____ Other 1.) 4'WIDE x 5' HIGH SLUICE GATE 2.) 5'WIDE STOP PLANK OPENING.

Material: Concrete _____ Metal _____ Other 1.) METAL SLUICE 2.) WOOD STOP PLANKS.

Size: ABOVE Length 12 ft.

Invert Elevations: Entrance 101.0 Exit 101.0

Physical Condition (Describe): Unobservable UPSTREAM

Material: CONCRETE DETERIORATED AT BASE

Joints: _____ Alignment NO MISALIGNMENT.

Structural Integrity: NO SIGNS OF STRUCTURAL INSTABILITY OBSERVED

Hydraulic Capability: _____

Means of Control: Gate ✓ Valve _____ Uncontrolled _____

Operation: Operable ✓ Inoperable _____ Other _____

Present Condition (Describe): BASE OF SLUICE GATE MECHANISM UNDER REPAIR.

9) Structural — LOCK STRUCTURE

a. Concrete Surfaces CONCRETE SURFACES IN LOCK CHAMBER DETERIORATE AT VERTICAL AND HORIZONTAL JOINTS (SEE PHOTOS)

b. Structural Cracking NONE OBSERVED SURFACE CRACKING ONLY.

c. Movement - Horizontal & Vertical Alignment (Settlement) NONE OBSERVED.

d. Junctions with Abutments or Embankments GOOD CONDITION. NO SEEPAGE OR OTHER EVIDENCE OF PROBLEMS NOTED

e. Drains - Foundation, Joint, Face LOCK DISCHARGE SYSTEM IN OPERATING CONDITION (SEE PHOTOS)

F. Water Passages, Conduits, Sluices OK

g. Seepage or Leakage NONE OBSERVED. - SOME SLIGHT SEEPAGE AT WALL TO LEFT OF LOWER LOCK GATE.

h. Joints - Construction, etc. SEE 9a.

i. Foundation NOT OBSERVED

j. Abutments SEE 9d

k. Control Gates ALL LOCK EQUIPMENT IN GOOD CONDITION AND OPERABLE

l. Approach & Outlet Channels CANAL - GOOD CONDITION.

m. Energy Dissipators (Plunge Pool, etc.) NONE.

n. Intake Structures NONE.

o. Stability NO EVIDENCE OF STRUCTURAL INSTABILITY DETECTED IN THE FIELD.

p. Miscellaneous —

10) Appurtenant Structures (Power House, Lock, Gatehouse, Other)

a. Description and Condition DATA FOR 9 above

REFERS TO LOCK STRUCTURE

11) Operation Procedures (Lake Level Regulation):

FLOW IN THE IMPOUNDMENT CONSISTS OF THE LOCK DISCHARGES FROM LOCKS 5 & 6 WHICH ARE LOCATED JUST UPSTREAM. THE CANAL IN THIS AREA IS A SIDE CHANNEL OF THE MOHAWK RIVER. MAIN CHANNEL FLOWS BY-PASS THIS SECTION BY OVERFLOWING THE DAM AT CRESCENT.

APPENDIX C

HYDROLOGIC/HYDRAULIC, ENGINEERING DATA AND COMPUTATIONS

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DESIGN BRIEF

PROJECT NAME N.Y.S. Dam Inspections DATE

SUBJECT Lock 4 PROJECT NO. 3686

Combined Headwater Curves of Crescent Dam and Lock 6 DRAWN BY

Elevation	Crescent Q *	Lock 6 Q	Total Q (cfs)
184	—	1010	1010
186	13,870	1110	14,980
188	44,600	1190	45,790
190	86,270	1270	87,540
192	136,850	1335	138,185
194	195,640	1770	198,410
196	260,290	6945	267,235
198	332,280	12,720	345,000
200	410,870	19,725	430,595
202	495,570	27,760	523,330
204	585,980	36,715	622,695

Flood	Combined Flow (cfs)	Elevation	Lock 6 Flow (cfs)
PMF	571,000	203.7	35,340
½ PMF	285,000	196.5	8,260

* Crescent Dam Headwater curve from "Phase I Inspection Report, National Dam Safety Program"

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DESIGN BRIEF

PROJECT NAME N.Y.S. Dam Inspections DATE

SUBJECT Lock 4 PROJECT NO. 1530

Spillway Headwater Rating Curve DRAWN BY

Q: $CLH^{3/2}$ "C" from King & Brater "Hand book of Hydraulics", [illegible]

L= 100 FT @ elev. 119.75

Elevation	H	C	Q
118	0	-	0
119	0.35	3.28	41
120	1.25	3.53	492
121	2.25	3.44	1161
122	3.25	3.30	1934
123	4.25	3.30	2891
124	5.25		3969
125	6.25		5156
126	7.25		6442
127	8.25		7820
128	9.25		9284
129	10.25		10,830

Auxiliary Spillway L = 44 ft. C = 3.65 @ elev. 133.0

Elevation	H	Q
133	0	0
134	1	64
135	2	180
136	3	330
137	4	509
138	5	711
139	6	935

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DESIGN BRIEF

PROJECT NAME N.Y.S. Dam Inspections DATE

SUBJECT Lock 11 PROJECT NO 3530

Tailwater Rating Curve DRAWN BY

Elevation	Q
115	0
116	40
120	490
130	1165
131	1990
132	3520
134	10,260
135	21,360
136	35,465

PMF Q = 35,340 cfs
Elev. = 136.0

Flow over spillway = 6500

½ PMF Q = 8360 cfs
Elev. = 133.7

Flow over spillway = 3645 cfs

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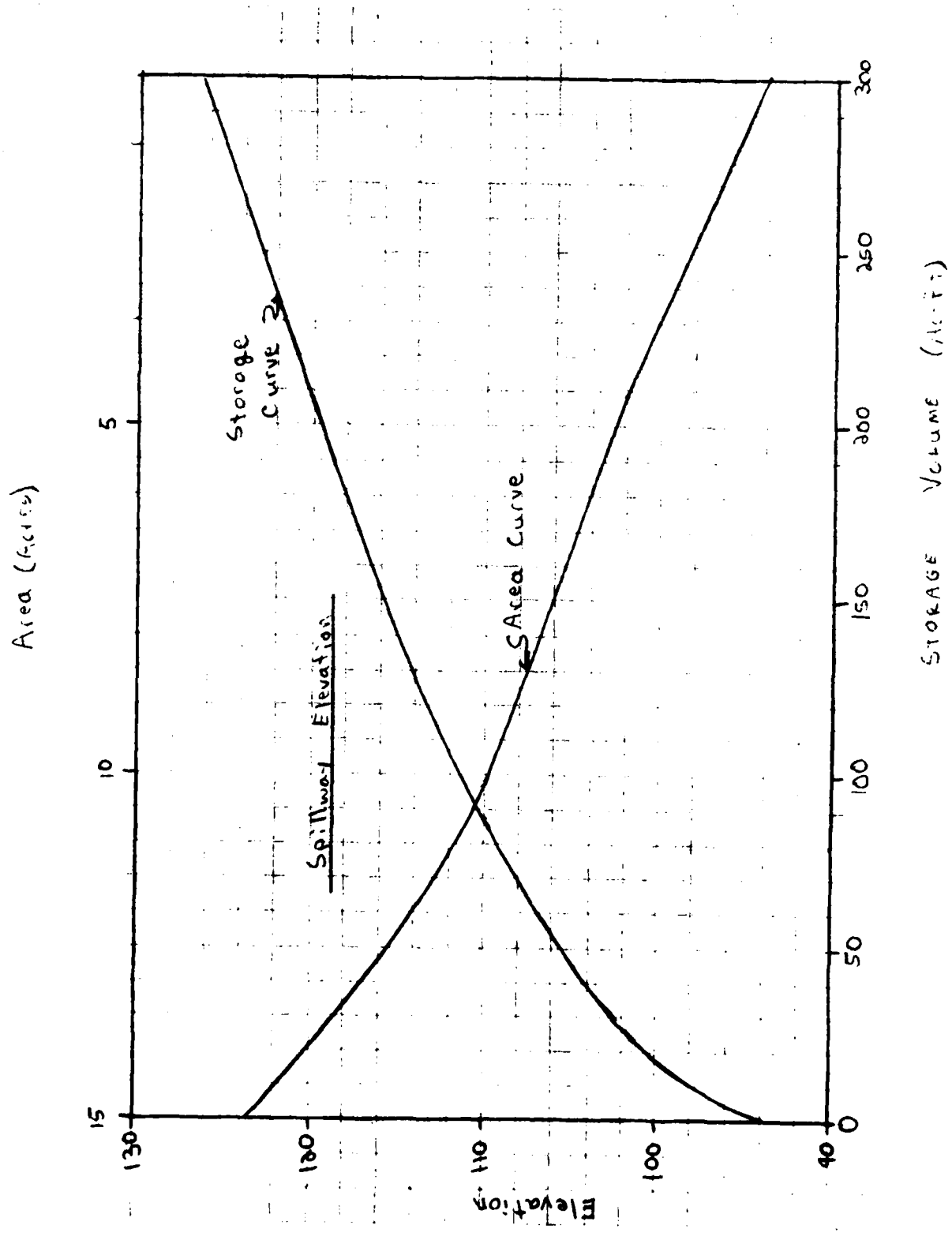
PROJECT NAME N.Y.S. Dam Inspections DATE

SUBJECT Lock 4 PROJECT NO. 2580

Area Capacity Curve DRAWN BY



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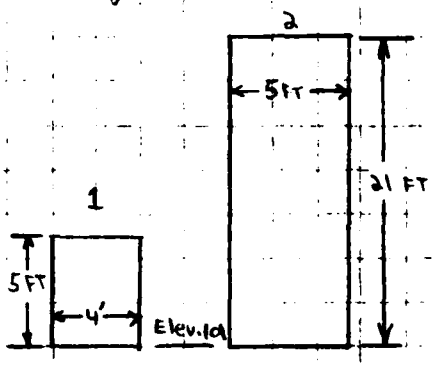
DESIGN BRIEF

PROJECT NAME N.Y.S. Dam Inspections DATE

JBJECT Lock 4 PROJECT NO. 2080

Reservoir Drain Discharge Rating DRAWN BY

Reservoir Discharges through 2, short rectangular culverts



Flows from "Design of Small Dams," by U.S. Bureau of Reclamation, p. B-13.
Scale (2)

Elevation	H_1	$(H/D)_1$	$(Q/w)_1$	Q_1	H_2	$(H/D)_2$	$(Q/w_2)^*$	Q_2	$(Q_T)_{(s)}$
Spillway Crest (118.75)	15.25	3.05	88	352	8.875	0.5	70	350	702
Top of Dam (133)	19.5	3.9	105	420	11.5	0.55	90	450	870

* Scale (2) extended to 21 FT.

CHECK LIST FOR DAMS
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

AREA-CAPACITY DATA:

	Elevation (ft.)	Surface Area (acres)	Storage Capacity (acre-ft.)
1) Top of Dam	123	15	250
2) Design High Water (Max. Design Pool)	N/A	—	—
3) Auxiliary Spillway Crest	N/A	—	—
4) Pool Level with Flashboards	N/A	—	—
5) Service Spillway Crest	118.75	13.5	190

DISCHARGES

	Volume (cfs)
1) Average Daily	N/A
2) Spillway @ Maximum High Water (Top of Dam)	2890
3) Spillway @ Design High Water	N/A
4) Spillway @ Auxiliary Spillway Crest Elevation	N/A
5) Low Level Outlet w/ water level at top of dam.	870
6) Total (of all facilities) @ Maximum High Water	3760
7) Maximum Known Flood	unknown
8) At Time of Inspection	120 ±

CREST: ELEVATION: 123

Type: Earthfill with concrete core

Width: 20 FT Length: 1750 FT

Spillover Concrete gravity spillway

Location Near right abutment

SPILLWAY:

PRINCIPAL		EMERGENCY
N/A	Elevation	111.75
	Type	inclined upstream face with rounded downstream corner
	Width	100 FT
	Type of Control	
	Uncontrolled	✓
	Controlled:	
	Type (Flashboards; gate)	
	Number	
	Size/Length	
	Invert Material	
	Anticipated Length of operating service	N/A
	Chute Length	N/A
	Height Between Spillway Crest & Approach Channel Invert (Weir Flow)	19 FT ±

HYDROMETEROLOGICAL GAGES:

Type : None at present

Location: _____

Records:

Date - _____

Max. Reading - _____

FLOOD WATER CONTROL SYSTEM:

Warning System: None at present

_____

Method of Controlled Releases (mechanisms):

4 ft. wide x 5 ft. high sluice-gated opening

5 ft. wide stop plank opening

DRAINAGE AREA: 140 acres

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: _____

Terrain - Relief: Moderately steep to steep

Surface - Soil: Not Known

Runoff Potential (existing or planned extensive alterations to existing (surface or subsurface conditions)

There are no known planned alterations to existing surface

Potential Sedimentation problem areas (natural or man-made; present or future)

Unknown

Potential Backwater problem areas for levels at maximum storage capacity including surcharge storage:

None Known

Dikes - Floodwalls (overflow & non-overflow) - Low reaches along the Reservoir perimeter:

Location: N/A

Elevation: _____

Reservoir:

Length @ Maximum Pool (½ PMF) 0.2 ± (Miles)

Length of Shoreline (@ Spillway Crest) 0.6 ± (Miles)

APPENDIX D

REFERENCES

APPENDIX D

REFERENCES

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APPENDIX E

STABILITY ANALYSIS

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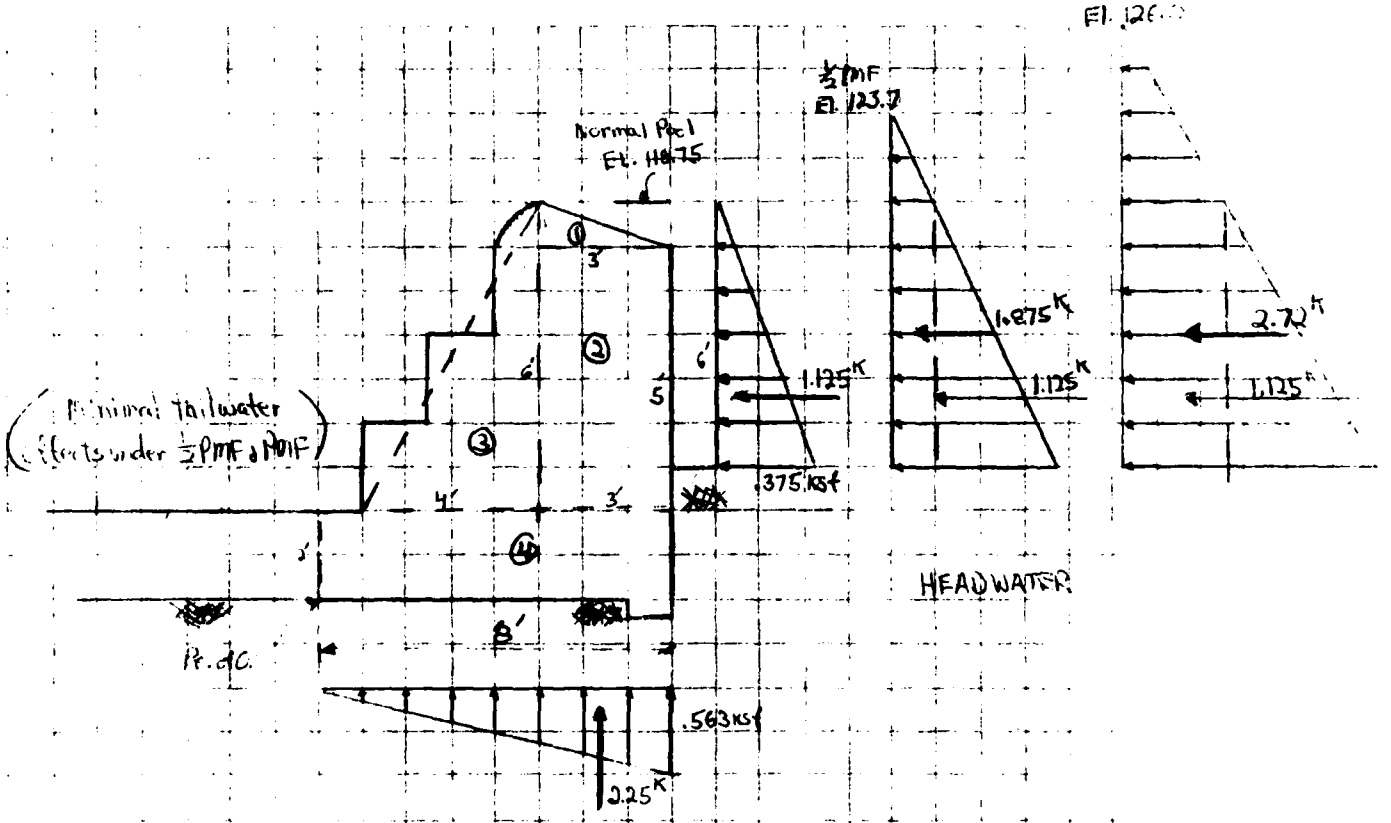
PROJECT NAME N.Y.S. Dam Inspections DATE 8/6/81

SUBJECT Stability Sec. E-E PROJECT NO.

Lock #4 Dam DRAWN BY C.C.R.



Wt. of Dam

① ½(3')(1')(.15pcf) = .225K

② (3')(5')(.15pcf) = 2.25K

③ ½(6')(4')(.15pcf) = 1.8K

④ (2')(8')(.15pcf) = 2.4K

6.675K

Summing Moments about the point of overturning

Resisting moment due to wt. of dam

$$M_R = \underset{(1.35)}{(.225^K)(6')} + \underset{(14.6\ldots)}{2.25^K(6.5')} + \underset{(6.6\ldots)}{(1.8^K)(3.67')} + \underset{(9.6)}{(2.4^K)(4')} = 32.\ldots^{K\text{-}ft}$$

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PROJECT NAME _____ DATE [illegible]

SUBJECT Stability, Sec. E-E PROJECT NO. _____

DRAWN BY _____

$$\bar{X} = \frac{M_R}{W_{e.o.}} = \frac{32.18^{k\text{-}ft}}{6.675^{k}} = 4.82' \text{ from } P_{e.o.}$$

$$\bar{Y} = \frac{\overset{(1.874)}{(.225^k)(8.33')} + \overset{(10.125)}{(2.25^k)(4.5')} + \overset{(7.2)}{(1.8^k)(4')} + \overset{(2.4)}{(2.4^k)(1')}}{6.675^k} = \frac{21.60^{k\text{-}ft}}{6.675^k} = 3.24' \text{ from } P_{e.o.}$$

$$\frac{3.24}{8}b = .41b$$

Uplift Moment

$$M_{up} = (2.25^k)(2/3 * 8) = 12^{k\text{-}ft}$$

$$\Sigma V = 6.675^k - 2.25^k = 4.425^k$$

Case I Normal Pool (@ El. 118.75 with uplift)

i) Overturning:

Overturning moment due to head water $1.125^k(5') = 5.625^{k\text{-}ft}$

Total overturning moment $M_o = 12^{k\text{-}ft} + 5.625^{k\text{-}ft} = 17.625^{k\text{-}ft}$

$$F.S. = \frac{M_R}{M_o} = \frac{32.18}{17.625} = 1.82$$

$$\frac{3.3}{8}b = .41b$$

Position of resultant: $d = \frac{\Sigma M}{\Sigma V} = \frac{32.18 - 17.625^{k\text{-}ft}}{4.425^k} = 3.3'$ from pt. of [illegible] within [illegible] third [illegible]

ii) Sliding $F.S. = \frac{\mu N + CA + \text{tailwater force}}{\text{driving force}}$

$$F.S. = \frac{\overset{(2.876)}{(.65)(4.425^k)} + \overset{(57.6)}{(0.05^{k\text{-}ft})(144^{k\text{-}ft})(8')}}{1.125^k} = 60.5$$

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PROJECT NAME _____ DATE [illegible]

SUBJECT [illegible] Sec. E-E PROJECT NO. _____

DRAWN BY [illegible]

Case II Winter Pool with Ice (water level at spillway crest)

Ice force = 5.0 k/ft Dam .dk @ El. 117.75

Overturning Moment due to ice $(5.0^k)(8') = 40^{k\text{-}ft}$

Total overturning moment $M_o = 40^{k\text{-}ft} + 17.625^{k\text{-}ft} = 57.625^{k}$

i) Overturning moment: $F.S. = \frac{M_R}{M_o} = \frac{32.18^{k\text{-}ft}}{57.625} = .56$ UNSTABLE

ii) Sliding: $F.S. = \frac{2.876^k + 57.6^k}{1.125^k + 5.0^k} = \frac{60.476}{6.125} = 9.9$

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PROJECT NAME _____ DATE _____

SUBJECT Stability Sec. F-E PROJECT NO. _____

DRAWN BY _____

Case III ½ PMF (Assuming uplift same as case I) (Headwater el. 123.7 Tailwater el. 110.0)

i) Overturning moment due to headwater

$$\underset{(5.625)}{1.125^k(5')} + \underset{11.25}{(1.875^k)\,6'} = 16.88^{k\text{-}ft}$$

$$\text{Total } M_o = 16.88^{k\text{-}ft} + 12^{k\text{-}ft} = 28.88^{k\text{-}ft}$$

$$F.S. = \frac{32.18^{k\text{-}ft}}{28.88^{k\text{-}ft}} = 1.1$$

$\frac{.74}{8}b = .0[illegible]$

$$\text{Position of Resultant } d = \frac{\Sigma M}{\Sigma V} = \frac{32.18 - 28.88}{4.425} = .74' \text{ not with [illegible] third of dam}$$

ii) Sliding

$$F.S. = \frac{60.476^k}{1.875^k + 1.125^k} = 20.2$$

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DESIGN BRIEF

PROJECT NAME _____ DATE _____

SUBJECT Stability, Sec. E-E PROJECT NO. _____

DRAWN BY _____

Case IV PMF (Assuming uplift of case I)

HEADWATER EL. 1260
TAILWATER EL. 112.5

i) Overturning moment due to head water

$$1.125^{k}(5') + 2.72^{k}(6') = 21.9^{k\text{-}ft}$$
$$(5.625) \qquad (16.32)$$

$$\text{Total } M_o = 21.9^{k\text{-}ft} + 12^{k\text{-}ft} = 33.9^{k\text{-}ft}$$

$$F.S. = \frac{M_R}{M_o} = \frac{32.18}{33.9} = 0.95 \quad \text{Unstable}$$

ii) Sliding

$$F.S. = \frac{60.476^{k}}{1.125^{k} + 2.72^{k}} = 15.7$$

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PROJECT NAME _____ DATE _____

SUBJECT Stability Sta. F-E PROJECT NO. _____

DRAWN BY _____

Case I Seismic loads (Zone 2 Horiz. EQ. coeff = 0.05
Vert. EQ. coeff = 0.025
Normal Pool El. 118.75)

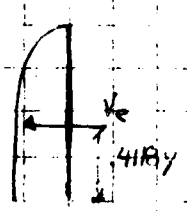
a) additional overturning due to accel. of gravity loads

$$0.05(\overset{(1.08)}{21.60^{k\text{-}ft}}) + 0.025(\overset{(0.804)}{32.18}) = 1.88^{k\text{-}ft}$$

Effective Σ Vert. loads

$$\Sigma V = 4.425^{k} - 0.025(\overset{(.167)}{6.675^{k}}) = 4.26^{k}$$

b) additional moment due to hydrodynamic effect of reservoir
(Ref. Design of Small Dams)



$Pe = C\zeta wh = 0.73(0.05)(0.0625\,lb^{3}) 6' = 0.014$

$Ve = 0.726\,Pe\,y = 0.726(0.014)\,6' = 0.061^{k}$

$Me = Ve\,\bar{y} = 0.061^{k}(6' + 0.4118 + 3') = 0.33^{k\text{-}ft}$

i) Overturning: $F.S. = \dfrac{32.18^{k\text{-}ft}}{1.88^{k\text{-}ft} + \underset{(19.805)}{17.525^{k\text{-}ft}} + 0.3^{k\text{-}ft}} = \underline{\underline{1.64}}$

Position of Resultant: $d = \dfrac{\Sigma M}{\Sigma V} = \dfrac{32.18 - 19.655^{k\text{-}ft}}{4.26^{k}} = 2.94'$ from [illegible]

$b\,\dfrac{2.94}{8} = .37b$

ii) Sliding

$$F.S. = \frac{.65(\overset{(2.77)}{4.26^{k}}) + 57.6^{k}}{1.125^{k} + 0.05(\underset{(.334)}{6.675^{k}}) + 0.061^{k}} = \underline{\underline{39.7}}$$

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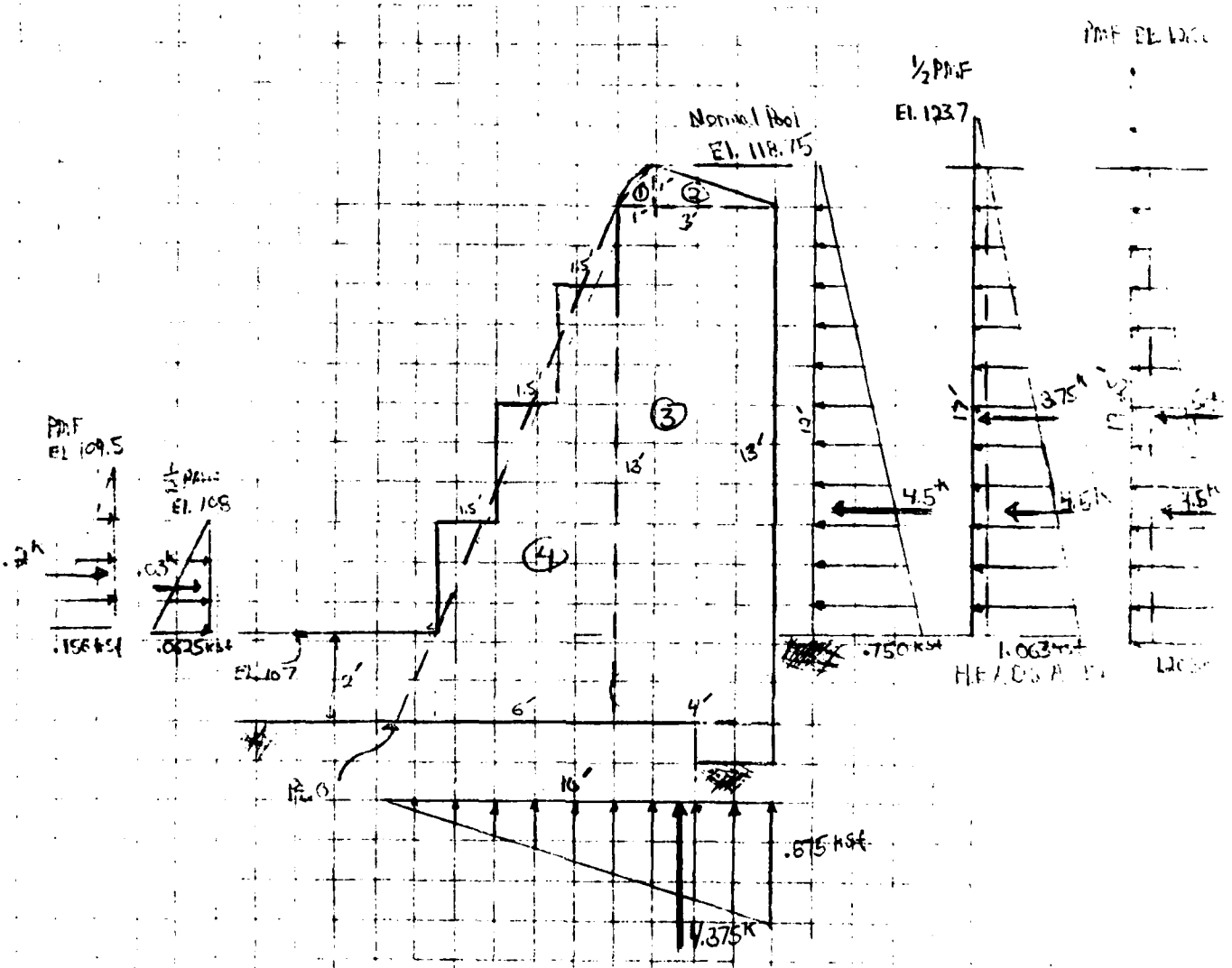
PROJECT NAME N.Y.S. Dam Inspections DATE [illegible]

SUBJECT Stability Sec. F-r PROJECT NO.

Lock #4 Dam DRAWN BY [illegible]



Wt of Dam

① ½(1')(1')(.15 pcf) = 0.075K

② ½(1')(3')(.15 pcf) = 0.225K

③ (4')(13')(.15 pcf) = 7.8K

④ ½(6')(13')(.15 pcf) = 5.85K

13.95K

Summing Moments about the point of overturning

Resisting moment due to dam wt

$M_R = (0.075^K)(6.33') + (0.225^K)(8.0') + (7.8^K)(8.0') + (5.85^K)(4.0') = 0^{\circ}$

(.47) (1.8) (62.4) (23.4)

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PROJECT NAME _____ DATE 8/ [illegible]

SUBJECT [illegible] PROJECT NO. _____

DRAWN BY _____

$\bar{X} = \frac{M_R}{W_D} = \frac{88.07}{13.95} = 6.31'$ from Pt. O

$\bar{Y} = \frac{(0.075^k)(13.3') + (0.225^k)(13.3') + (7.8^k)(6.5') + (5.87^k)(6.5')}{13.95^k} = \frac{92.715}{13.95}$ 6.65' from Pt. [illegible]

(.9975) (2.9925) (50.7) (38.025)

.66b

Uplift Moment

$M_{up} = 4.375^k(2/3 * 10') = 29.17^{k\text{-}ft}$

$\Sigma V = 13.95^k - 4.375^k = 9.575^k$

Case I Normal Pool (@ El. 18.[illegible] with uplift)

a) Overturning

Overturning Moment due to [illegible] water

$4.5^k(6') = 27^{k\text{-}ft}$

Total Overturning Moment

$M_O = 29.17^{k\text{-}ft} + 27^{k\text{-}ft} = 56.17^{k\text{-}ft}$

$F.S. = \frac{M_R}{M_O} = \frac{88.07}{58.35} = \underline{\underline{1.51}}$

Position of Resultant: $d = \frac{\Sigma M}{\Sigma V} = \frac{88.07 - 56.17}{9.575} = 3.33'$ from Pt. O [illegible] middle third of dam.

.33

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PROJECT NAME _____ DATE 8/[illegible]

SUBJECT [illegible] Sec. F-F PROJECT NO. _____

DRAWN BY _____

ii) Sliding Factor of Safety = $\mu N + CA$ + Tailwater Force / Driving Force

$$F.S. = \frac{.65(9.575^k)_{(6.224)} + (0.05\,ksi)(144\,\frac{m^2}{ft^2})(1')(10')_{(72.0)}}{4.5^k} = \frac{78.22}{4.5} = 17.4$$

Case I Winter Pool with Ice (water level at spillway crest)

Ice force = 5.0^k/ft width of dam @ EL. 117.75

Overturning Moment due to Ice $(5.0^k)(13') = 65^{kft}$

Total Overturning Moment $M_o = 56.17^{kft} + 65^{kft} = 121.17^{kft}$

i) Overturning: $F.S. = \frac{M_R}{M_o} = \frac{88.07}{121.17} = .73$ UNSTABLE

ii) Sliding: $F.S. = \frac{78.22^k}{4.5^k + 5.0^k} = 8.2$

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DESIGN BRIEF

PROJECT NAME _____ DATE _____

SUBJECT Stability Sec F-F PROJECT NO. _____

DRAWN BY _____

Case III ½ PMF (Assuming uplift same as case I) (Head water el. 123.7 Tailwater el. 108)

i) Overturning moment due to headwater

$$4.5^{K}_{(27)}(6') + 3.75^{K}_{(30)}(8') = 57.0^{K\text{-}ft}$$

Total moment $M_o = 57.0^{K\text{-}ft} + 29.17^{K\text{-}ft} = 86.17^{K\text{-}ft}$

Resisting moment due to tailwater (negligable)

$$F.S. = \frac{M_R}{M_o} = \frac{88.07^{K\text{-}ft}}{86.17^{K\text{-}ft}} = 1.02$$

Position of Resultant $d = \frac{\Sigma M}{\Sigma V} = \frac{89.01 - 86.17^{K\text{-}ft}}{9.575^{K}} = 0.2'$ from point of toe.

.026

ii) Sliding

$$F.S. = \frac{78.22^{K}}{4.5^{K} + 3.75^{K}_{(0.35)}} = 9.5$$

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DESIGN BRIEF

OJECT NAME _____ DATE 5/[illegible]

BJECT Stability Sec. F-F PROJECT NO. _____

DRAWN BY _____

Case IV PMF (Assuming uplift same as case I) (Headwater el 1260 Tailwater el 1095)

i) Overturning moment due to tailwater

$$4.5^{k}_{(27)}(6') + 5.44^{k}_{(43.5)}(8') = 70.5^{k\text{-}ft}$$

Total Overturning moment $M_O = 70.5^{k\text{-}ft} + 29.17^{k\text{-}ft} = 99.7^{k\text{-}ft}$

Resisting moment due to tailwater

$$.2^{k}(2.93') = 0.57^{k\text{-}ft}$$

Total $M_R = 0.57^{k\text{-}ft} + 88.07^{k\text{-}ft} = 88.6^{k\text{-}ft}$

$$F.S. = \frac{M_R}{M_O} = \frac{88.6^{k\text{-}ft}}{99.7^{k\text{-}ft}} = 0.99 \quad \text{Unstable}$$

ii) Sliding

$$F.S. = \frac{78.22^{k} + 0.2^{k}}{4.5^{k} + 5.44^{k}} = 7.9$$

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PROJECT NAME _____ DATE 8/6/[illegible]

SUBJECT [illegible] Sec. F F PROJECT NO. _____

DRAWN BY _____

Case V Seismic loads (Zone 2 Horiz. EQ. Coeff = 0.05
Vert. E.G. Coeff = 0.025
Normal Pool El. 118.75)

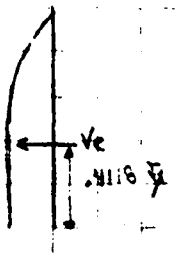
a) additional overturning due to accel. of gravity loads.

$$0.05\,(\overset{(4.636)}{92.715^{k\text{-}ft}}) + 0.025\,(\overset{(2.202)}{88.07^{k\text{-}ft}}) = 6.838^{k\text{-}ft}$$

Effective Σ Vert. loads

$$\Sigma V = 9.575^{k} - 0.025(13.95^{k}) = 9.226^{k}$$

b) additional moment due to hydrodynamic effect of the reservoir.
(Ref "Design of Small Dams")



$$Pe = C\,\zeta\,wh = 0.73(0.05)(0.0624\ \text{[illegible]})\,12' = 0.0274$$

$$Ve = 0.726\,Pe\,y = 0.726(0.0274)\,12' = 0.239^{k}$$

$$Me = Ve\,\bar{y} = 0.239^{k}\{(12' * 0.4118) + 2'\} = 1.66^{k\text{-}ft}$$

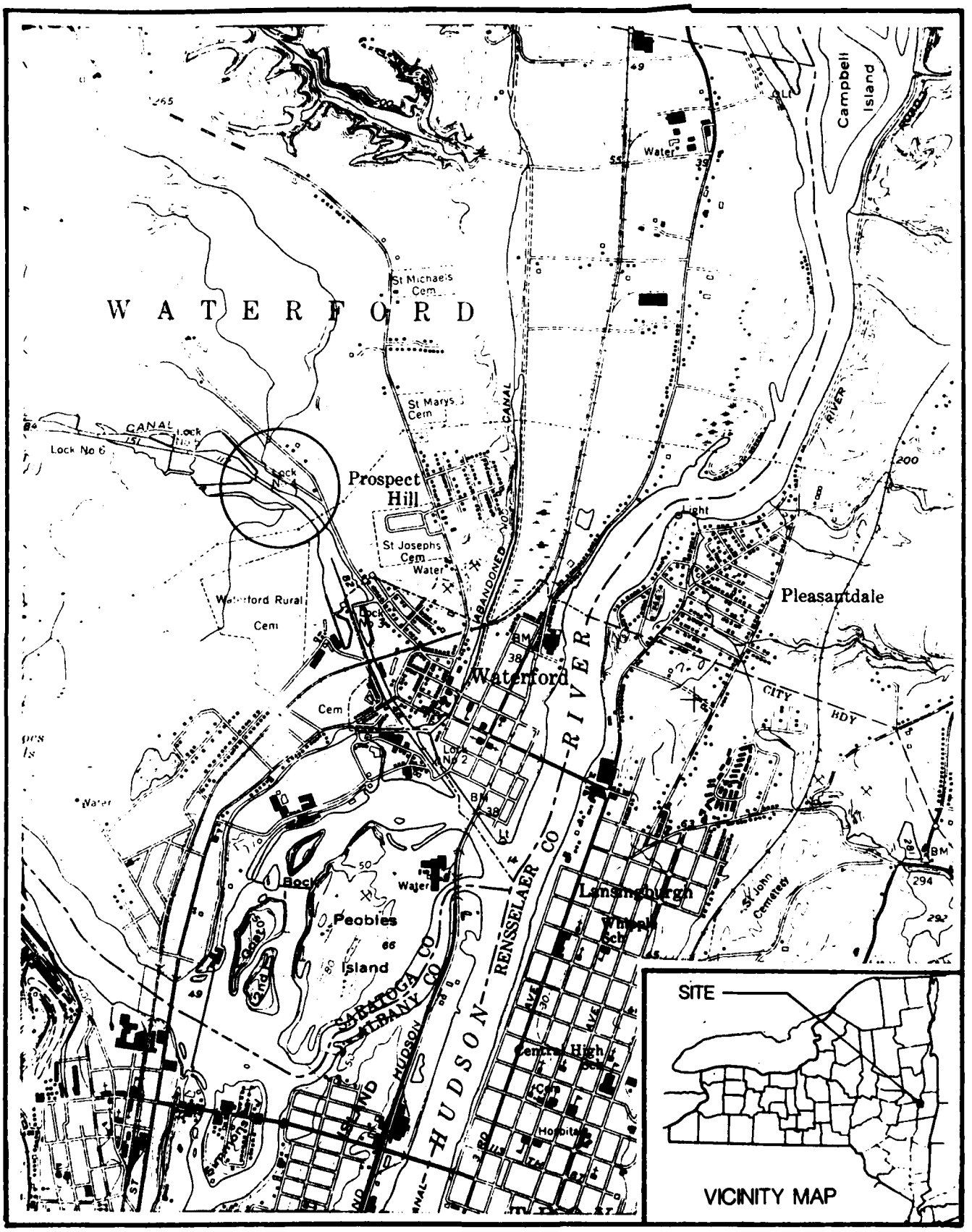
i) Overturning: $F.S. = \dfrac{88.07^{k\text{-}ft}}{6.84^{k\text{-}ft} + \underset{(64.7)}{1.66^{k\text{-}ft}} + 56.17^{k\text{-}ft}} = 1.37$

Position of Resultant: $d = \dfrac{\Sigma M}{\Sigma V} = \dfrac{88.07 - 64.9}{9.226} = 2.59$ NOT [illegible] middle third [illegible]

ii) Sliding: $F.S. = \dfrac{.65(\overset{(6.0)}{9.226^{k}}) + 72^{k}}{4.5^{k} + 0.05(\underset{(6.975)}{13.95^{k}}) + 0.239^{k}} = \underline{\underline{14.3}}$

APPENDIX F

DRAWINGS



PROJECT BOUNDARY

LOCATION PLAN

FIGURE 1

SCALE

1000 0 1000 2000 3000 4000

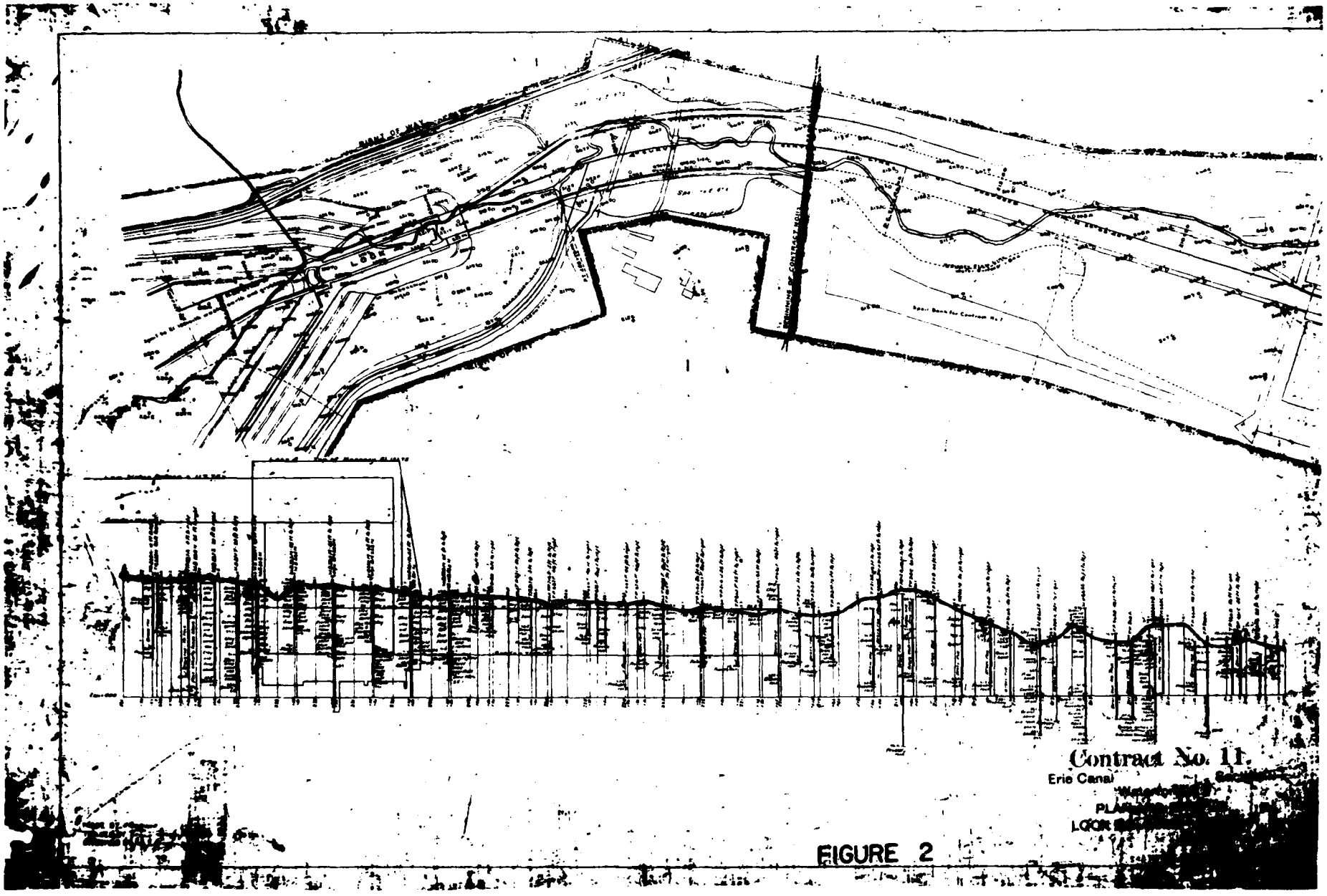


FIGURE 2

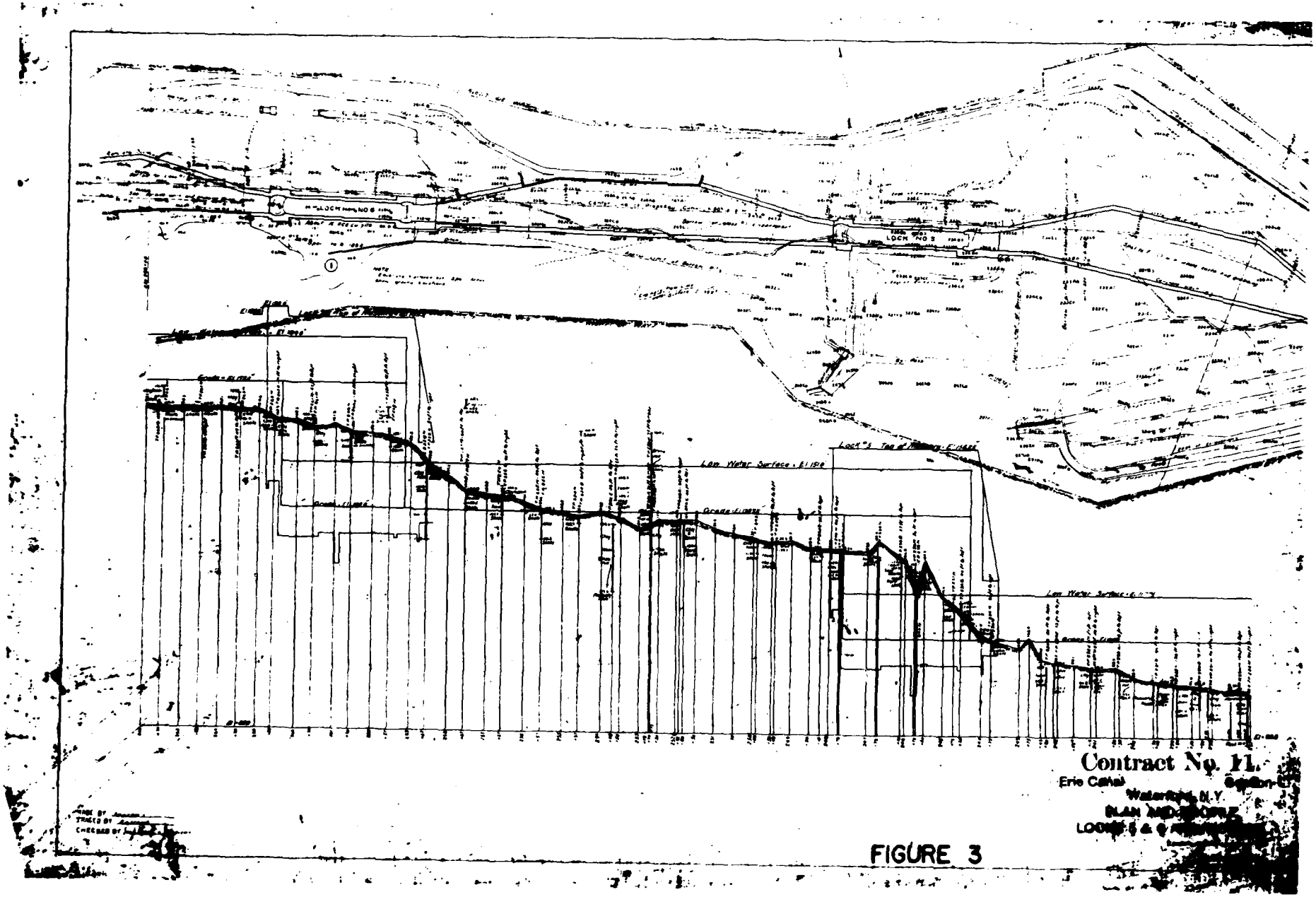

LOCK NO 8
LOCK NO 7
LOCK NO 6
Low Water Surface - El 194
Contract No. 11.
Erie Canal
Waterford, N.Y.

FIGURE 3

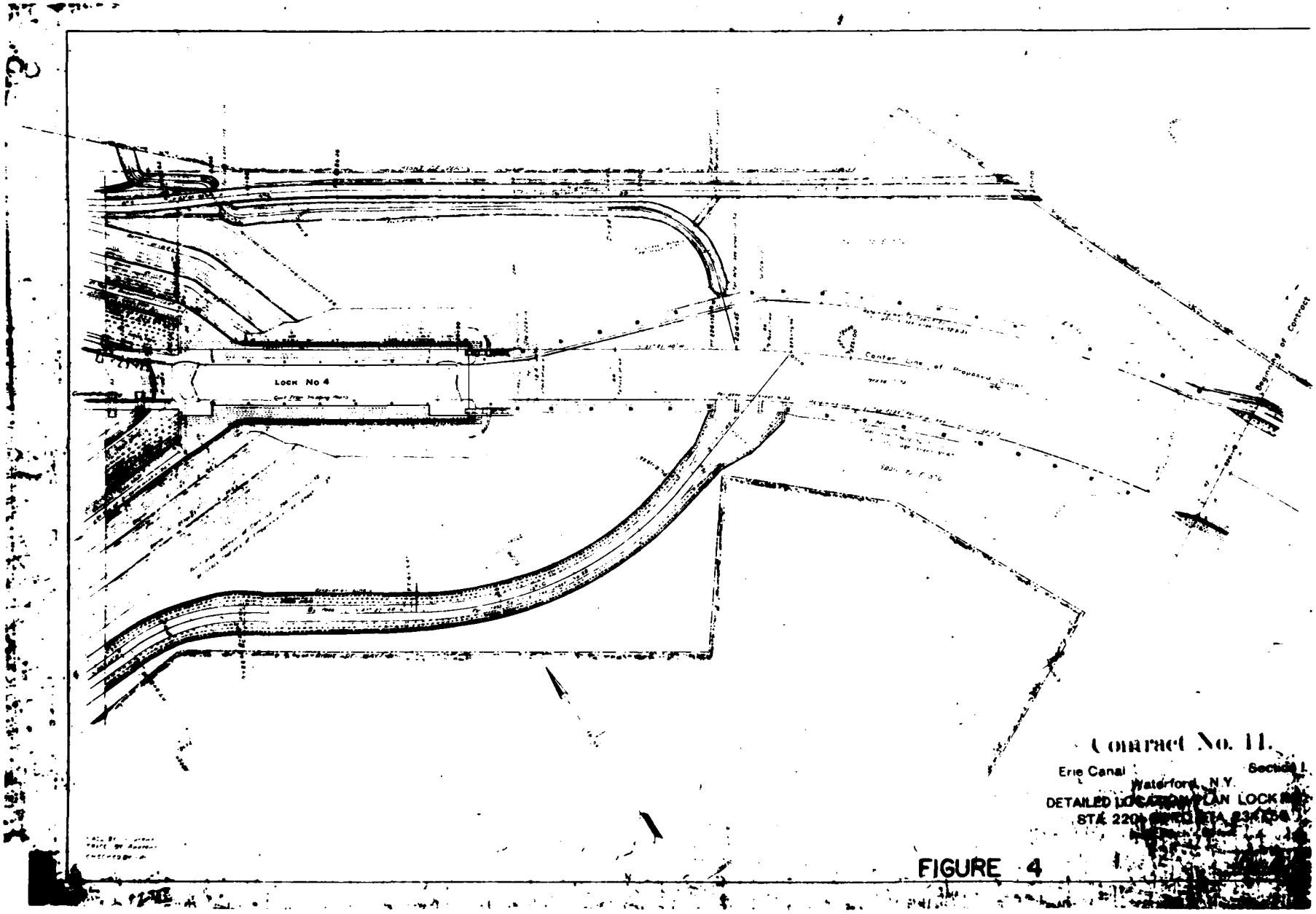

Lock No 4
Beginning of Contract
Contract No. 11.
Erie Canal
Section 1
Waterford, N.Y.
DETAILED LOCATION PLAN LOCK

FIGURE 4

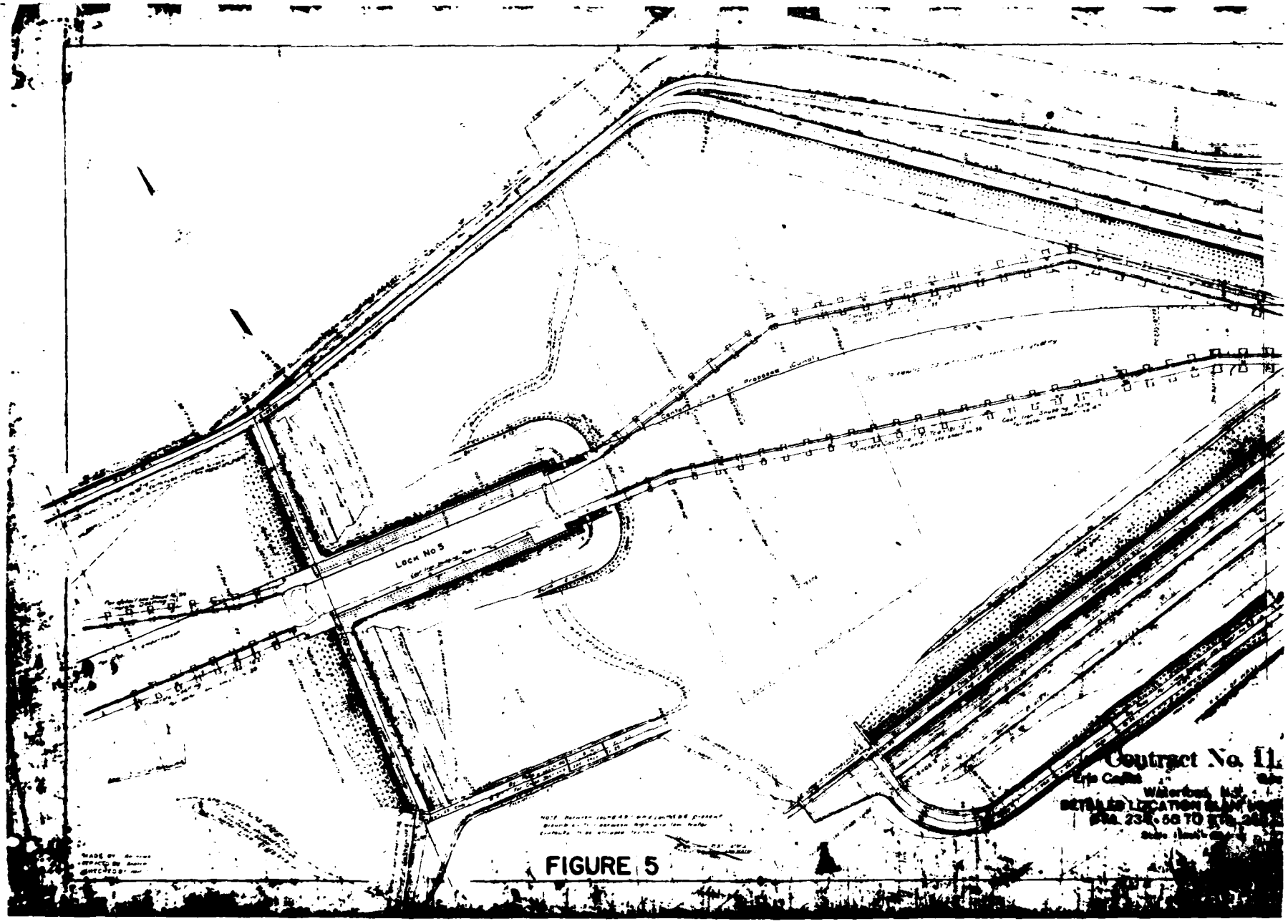


FIGURE 5

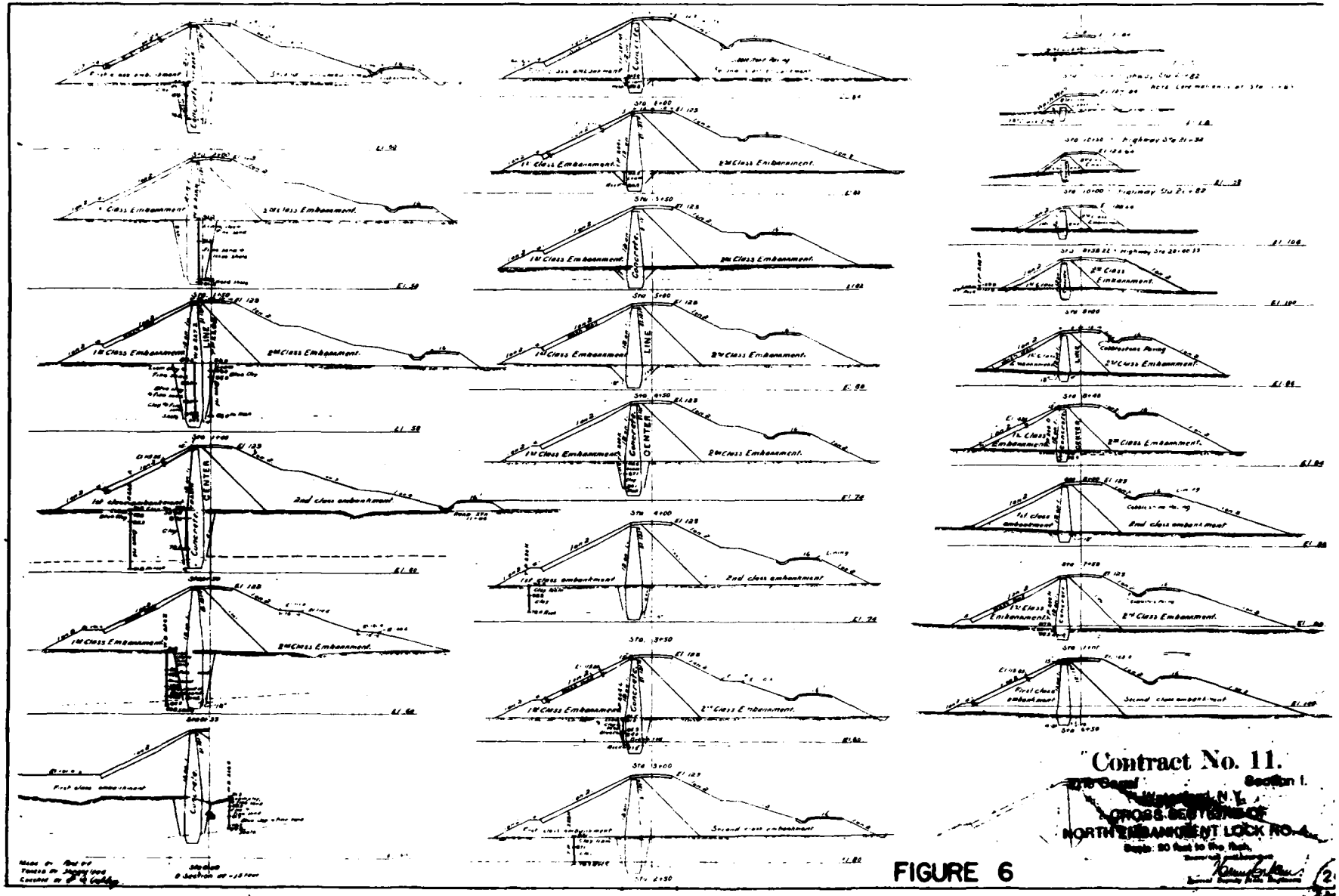

Contract No. 11.
Section I.
CROSS SECTIONS OF
NORTH EMBANKMENT LOCK NO. 4.
Scale: 20 feet to the inch.
1st Class Embankment
2nd Class Embankment
1st class embankment
2nd class embankment
First class embankment
Second class embankment
CENTER LINE
Concrete
Highway Sta 21+32
Highway Sta 21+82
Cobblestone Paving

FIGURE 6

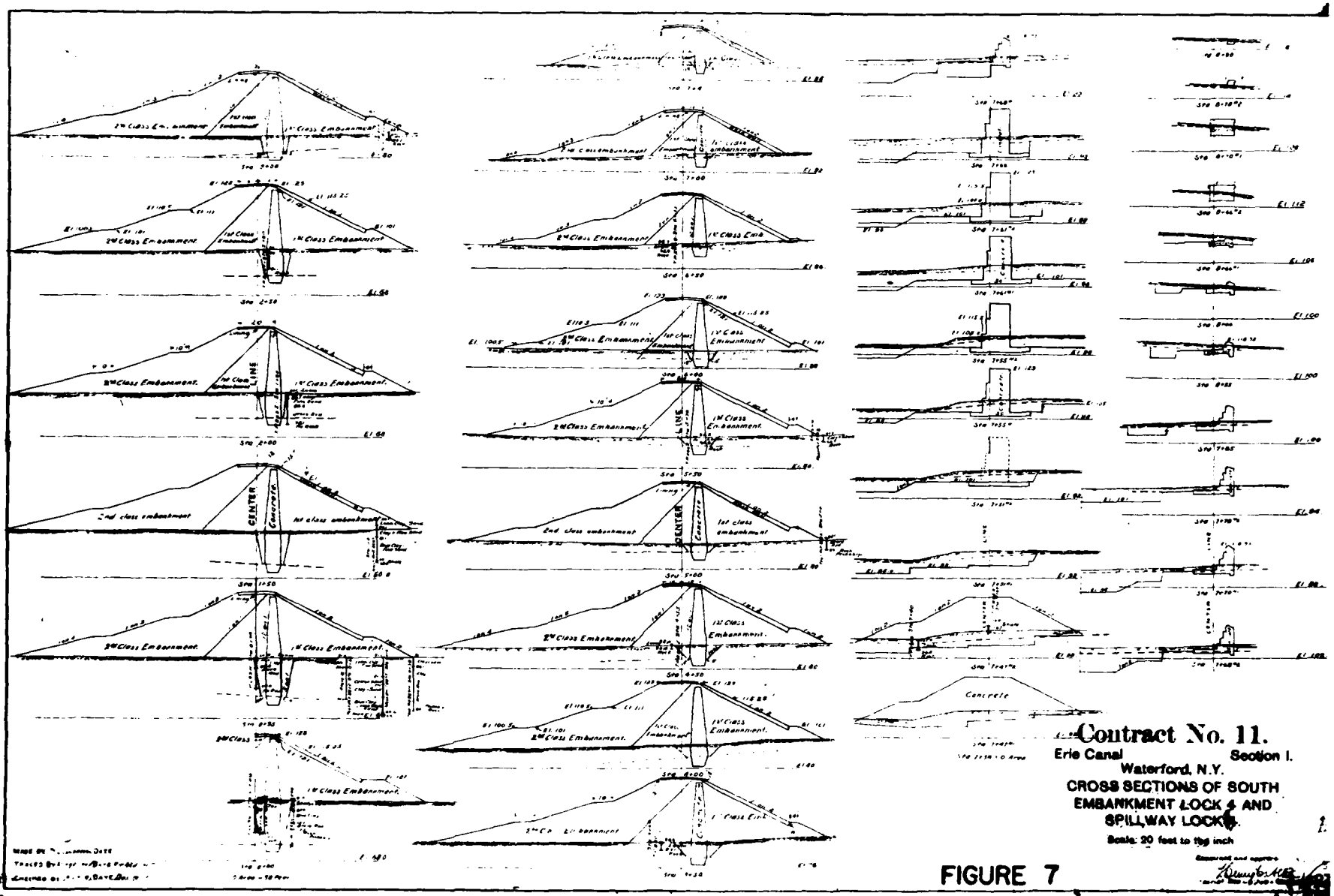

Contract No. 11.
Erie Canal
Section I.
Waterford, N.Y.
CROSS SECTIONS OF SOUTH EMBANKMENT LOCK 4 AND SPILLWAY LOCK 5.
Scale: 20 feet to the inch

FIGURE 7

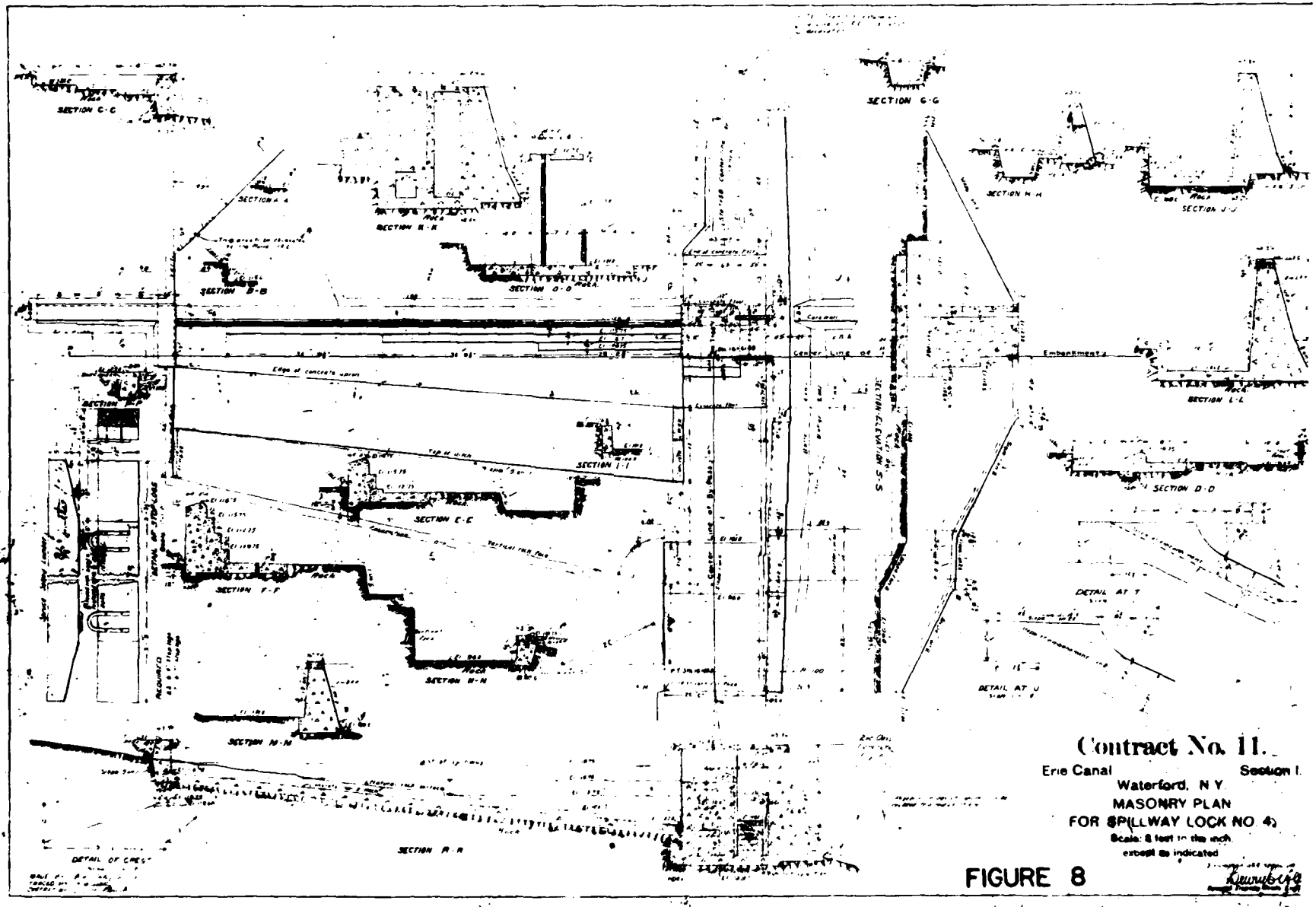

SECTION C-C
SECTION A-A
SECTION B-B
SECTION E-E
SECTION D-D
SECTION G-G
SECTION H-H
SECTION J-J
SECTION K-K
SECTION L-L
SECTION I-I
SECTION E-E
SECTION F-F
SECTION M-M
SECTION N-N
SECTION R-R
SECTION D-D
DETAIL AT T
DETAIL AT U
DETAIL OF CREST
Embankment
Contract No. 11.
Erie Canal
Section I.
Waterford, N.Y.
MASONRY PLAN
FOR SPILLWAY LOCK NO. 4
Scale: 8 feet to the inch
except as indicated

FIGURE 8

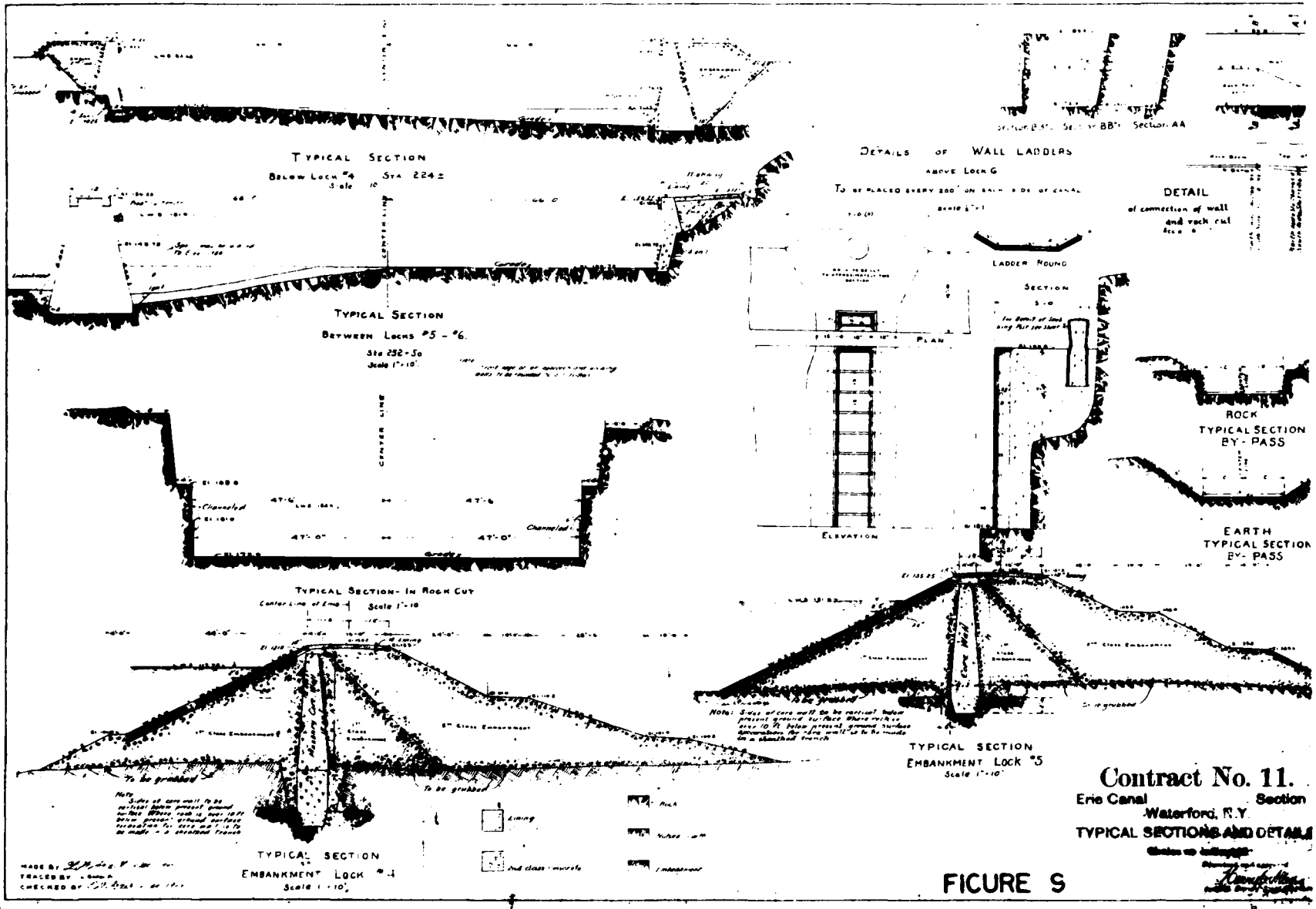

TYPICAL SECTION
BELOW LOCK #4 STA 224±
TYPICAL SECTION
BETWEEN LOCKS #5 - #6.
Sta 252-50
Scale 1"=10'
CENTER LINE
TYPICAL SECTION- IN ROCK CUT
Scale 1"=10'
TYPICAL SECTION
EMBANKMENT LOCK #4
Scale 1"=10'
To be grubbed
Lining
2nd class concrete
Rock
Embankment
DETAILS OF WALL LADDERS
ABOVE LOCK 6
LADDER ROUND
SECTION
PLAN
ELEVATION
DETAIL
of connection of wall
and rock cut
ROCK
TYPICAL SECTION
BY-PASS
EARTH
TYPICAL SECTION
BY-PASS
TYPICAL SECTION
EMBANKMENT LOCK #5
Scale 1"=10'
Contract No. 11.
Erie Canal Section
Waterford, N.Y.
TYPICAL SECTIONS AND DETAILS
MADE BY
TRACED BY
CHECKED BY

FIGURE 9

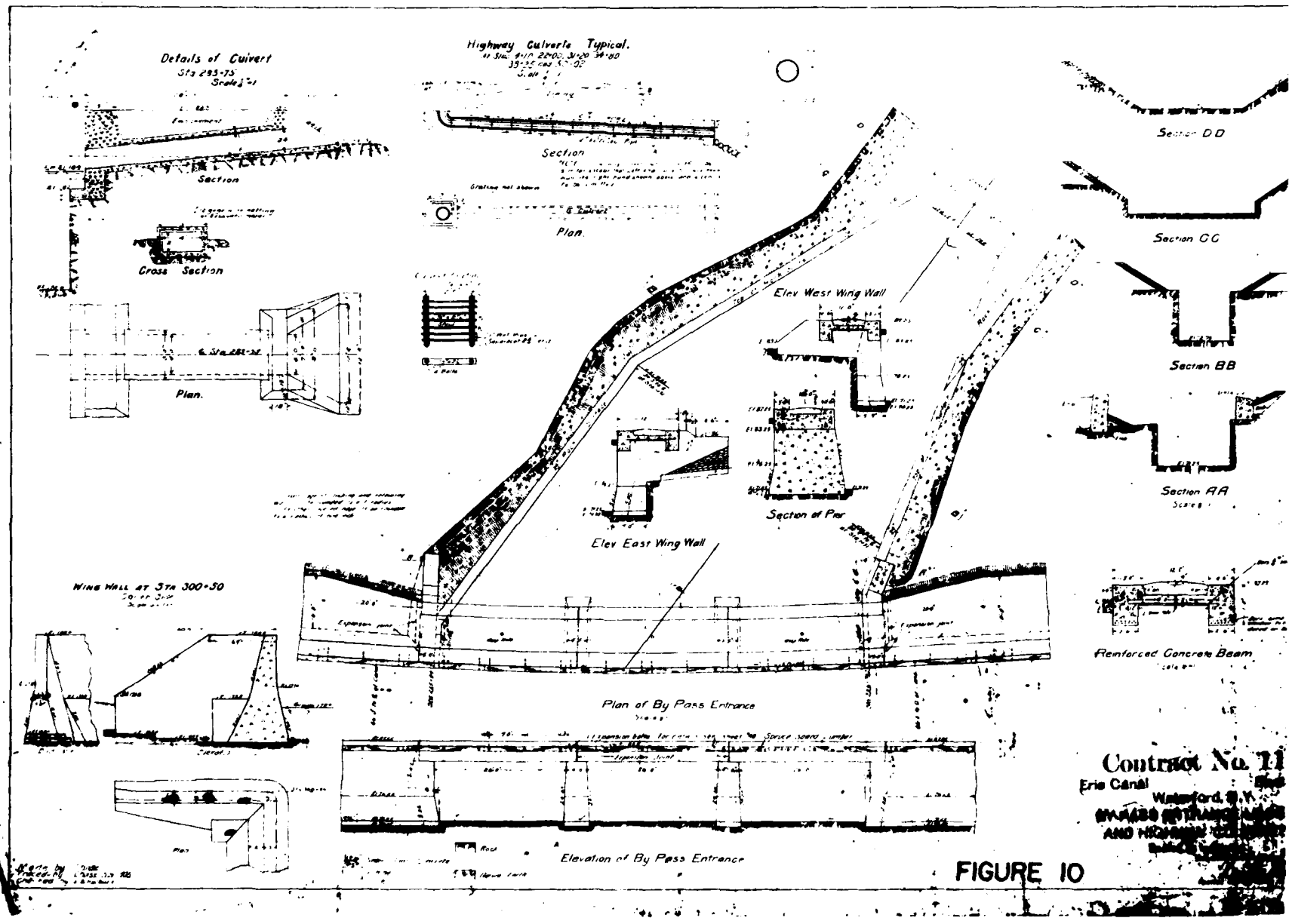
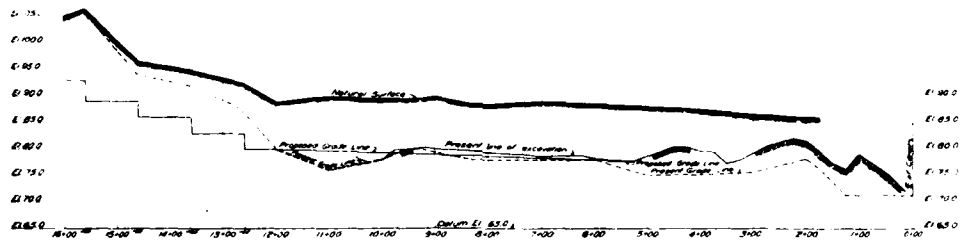
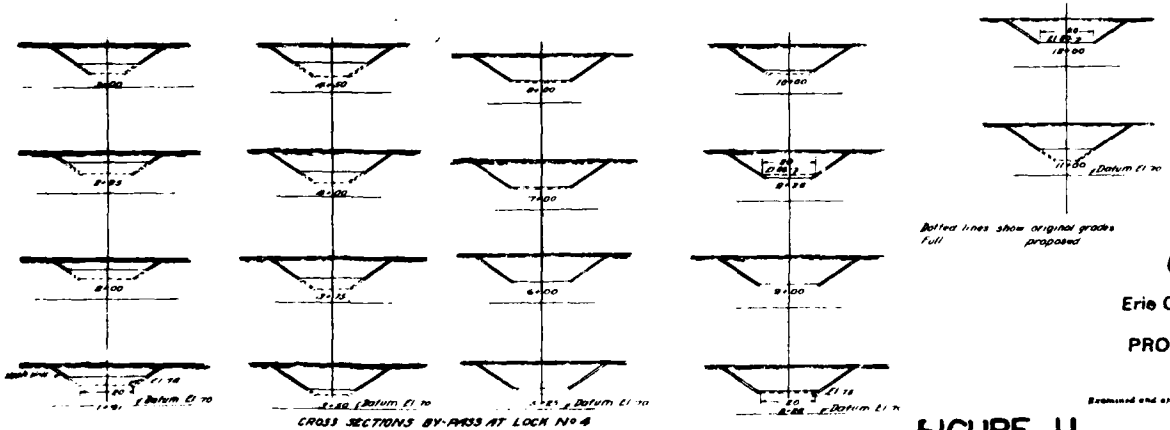

Details of Culvert
Sta 295+75
Scale
Section
Cross Section
Plan.
Highway Culverts Typical.
Section
Plan.
Elev West Wing Wall
Section of Pier
Elev East Wing Wall
Section DD
Section CC
Section BB
Section AA
Reinforced Concrete Beam
WING WALL AT STA 300+50
Plan of By Pass Entrance
Elevation of By Pass Entrance
Contract No. 11
Erie Canal
Waterford, N.Y.

FIGURE 10



PROFILE ALONG CENTER LINE OF
BY-PASS AT LOCK No 4

Scales { Horizontal 1" = 100
Vertical 1" = 10



CROSS SECTIONS BY-PASS AT LOCK No 4
Scale 1" = 20

Dotted lines show original grades
Full proposed

Contract No. 11.

DETAIL SHEET NO 2

Erie Canal Section I

Waterford, N.Y.

PROFILE & CROSS SECTIONS OF
BY-PASS AT LOCK 4

Scales as indicated

FIGURE 11

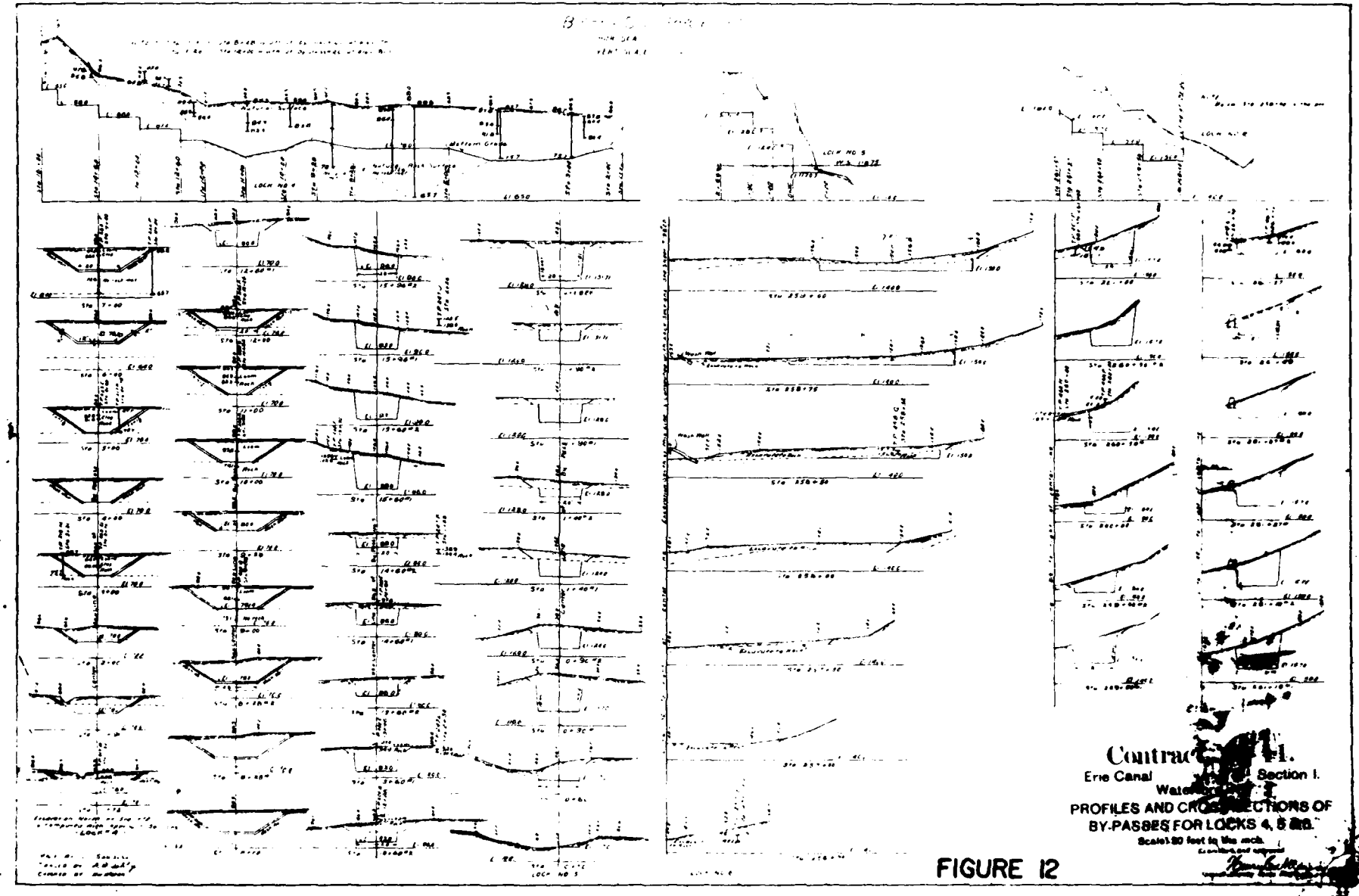
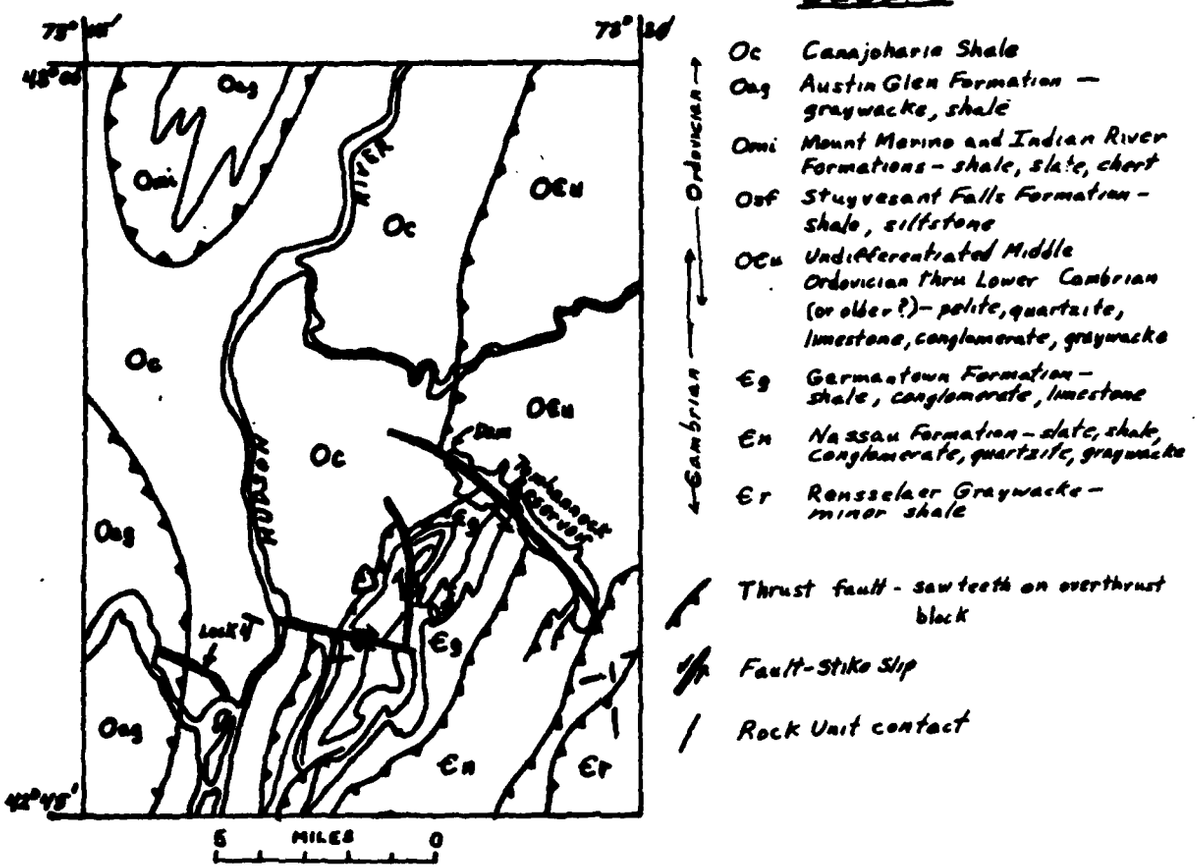

Contract No. 41.
Erie Canal Section I.
PROFILES AND CROSS SECTIONS OF
BY-PASSES FOR LOCKS 4, 5 and 6.
Scale 1 50 feet to the inch.

FIGURE 12



Generalized Geologic Map

FIGURE 13